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New Zealand Department of Agriculture.

JOHN D. RITCHIE, Secretary.

VITICULTURAL DIVISION.

VITICULTURE IN NEW ZEALAND

(WITH SPECIAL REFERENCE TO AMERICAN VINES).

BY

ROMEO BRAGATO

(ŒNOTECHNIC),

Diploma R.S.S.V.Œ. Conegliano, Superintendent of Viticultural Stations, Viticulturist and Œnologist to the Government of New Zealand.

HON. T. Y. DUNCAN, MINISTER FOR AGRICULTURE.

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PREFACE.

The primary object of this book is to deal with viticulture generally as applied to New Zealand, with special reference to the American vines With this end in view, the work has been made as useful and complete as the limited time at the author's disposal would permit.

The ravages of the dreaded phylloxera are known to most of my readers, and its presence here in New Zealand leads me to again impress upon growers the necessity for replanting their vineyards upon a phylloxera-resistant basis. It is the only hope of saving viticulture from extinction; and the fact that in France alone 3,000,000 acres have been planted with American vines as stocks should satisfy the most conservative grower on this point.

Having in view the great variations of soil and climate in the different parts of the colony, I have taken pains to point out the American vines most suited to the varying environments.

It is intended to follow this book with further publications dealing with "Wine-making and Cellar-management," "Analysis of Wines," "The Manufacture of Unfermented Wines," "Grape-culture under Glass," and "The Diseases and Pests of Grape-vines."

R. B.

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INTRODUCTION.

In the following work I have endeavoured to compile a general guide to grape-growing in New Zealand. Many excellent works on viticulture are in existence, but, unfortunately, they are mostly in foreign languages, those in English being confined principally to grape-culture under glass; whilst in all cases they are written for other countries, and are consequently unsuited for local application, where different climatic conditions prevail.

An erroneous idea exists in the minds of many here that the climate of New Zealand is not favourable to the production of wine-grapes. The first chapter of this book will, I trust, dispel this delusion. On the other hand, there are thousands of acres of so-called "poor land" in the northern portions of the colony, at present lying idle and unproductive, which are admirably adapted for wine-growing.

I would like to state here that it has been physically impossible for me to accept all the invitations I have received from grape-growers and intending planters to visit them personally; I trust this little work will, in my unavoidable absence, assist the grower in any difficulty he may have to face.

In writing, I have kept constantly before me the practical needs of those settlers who possess no special knowledge of viticulture, whilst it is written as much for the new-comer as for those already settled on the land.

I make no claim to originality in this work, but would gratefully acknowledge the generous way in which the established growers have placed at my disposal the benefits of the lessons learnt in their often dearly bought experience.

I cherish the conviction that the sentiment which has prompted me—the welfare and future prosperity of the vine-growers in this colony—will be productive of some benefit, and that my good intentions will secure the kind reader's indulgence for its many imperfections.

R. BRAGATO.

Auckland, May, 1905.

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VITICULTURE IN NEW ZEALAND.

VITICULTURE IN NEW ZEALAND.

CHAPTER I.

CLIMATE.

The most important factor in the production of wine-grapes is that of climate, In a climate which is too cold the fruit does not reach perfection, whilst in a climate which is too warm the grape becomes an evergreen, with a continuous production of inferior fruit.

The ideal climate is found in those countries where the summer is sufficiently warm to ripen the fruit perfectly, and the winter cold enough to insure the return of the sap to the roots after the maturing of the berries, thus securing to the vine a "spell," or period of rest. At the same time, extremes of climate are highly undesirable: extreme heat in the summer causes scorching and wilting of the vine, and an excess of saccharine matter in the fruit; consequently the wine produced is very syrupy, with a corresponding deficiency in acidity. On the other hand, extreme cold in winter is liable to extend into the spring, with disastrous effect upon the young buds just bursting.

The following table shows the temperatures best suited to the grape at its different stages of growth :—

Period.	Temperature best suited. Deg. Fahr.
During bursting of the buds	53–55
During blossoming and the setting of the fruit	64
During period of maturing	62–70
During the last forty days, for the perfect ripening of the fruit, a mean daily temperature of at least	66

These, then, may be taken as the temperatures for the production of a perfect wine-grape. At the same time, a considerable range both above and below these figures is allowable, and with the variation in temperature from this standard appears a corresponding variation in the components of the wine produced.

In Europe the cultivation of wine-grapes extends from Germany to the southern limits of Europe, and from the table given it will be observed that with the rise in the mean annual temperature of the country there is

a proportionate increase in the alcoholic strength of the wine, and generally a corresponding loss of acidity. This is due to the fact referred to, that the warmer climates produce a much sweeter grape, and it is from the saccharine matter of the fruit that the alcohol in the wine is produced.

	Average. Alcohol per 100. By Volume.	Acidity per 1,000.
Germany	10·08	6·8
France	10·34	6·0
Austria-Hungary	11·70	6·4
Italy	12·75	6·2
Spain	14·05	3 to 5

Thus the wines of Germany—the coldest of the countries named—contain the lowest percentage of alcohol, whilst those of the hottest—Spain—are 40 per cent. higher in alcoholic strength.

A comparison of the wines made in this country shows that this rule holds good here.

	Average. Alcohol per 100. By Volume.	Acidity per 1,000.
Hawke's Bay	11·00	7·25
Waerenga, Waikato	11·10	6·5
Kaipara	12·04	6·4

For the purposes of comparison I append a detailed analysis of the wines of the Province of Florence, famous for the production of Chianti, together with a similar analysis of those of New Zealand.

Place of Production.	Year of Vintage.	Name of Grape.	Chemical Composition of the Wine. Alcohol per 100. By Volume.	Per 1,000. Acidity as Tartaric Acid.	Extractive Matter.	Tannic Acid.	Bitartrate of Potash.
PROVINCE OF FLORENCE.							
Montopoli ..	1874	Red	9·90	5·94	13·25	0·709	2·344
Regello ..	1882	„	9·60	6·62	29·00	0·791	3 081
Carmignano ..	1883	„	13·30	6·18	21·25	0·967	1·974
Regello .	1883	„	10·60	6·76	22 50	1·016	3·081
„ ..	1884	„	10·30	6 77	22·50	1 791	3·466
Carmignano ..	1888	„	11·40	5·88	22·50	0 903	3·466
Figline ..	1888	„	10·10	6·32	17·50	0 935	2·528
Barberino d'Elsa	1888	„	12·00	6·18	16·75	0·693	2 528

Place of Production.	Year of Vintage.	Name of Grape.	Chemical Composition of the Wine.				
			Alcohol per 100. By Volume.	Per 1,000.			
				Acidity as Tartaric Acid.	Extractive Matter.	Tannic Acid.	Bi-tartrate of Potash.
NEW ZEALAND.							
Te Mata, Hawke's Bay	1903	Shiraz ..	11·75	6·84	24·00	1·150	1·020
Ditto	1903	Cabernet ..	12·75	6·20	26·00	1·780	1·200
„	1903	White ..	12·50	7·00	16·00	1·100	2·080
„	1900	Red	12·00	7·48	19·20	1·300	1 500
„	1899	White ..	12·00	6·83	14·30	0·500	2 040
Greenmeadows, Hawke's Bay	1897	„ ..	10·60	9·52	16·00	0·800	1·700
Ditto	1898	„ ..	10·00	9·52	15·20	0·750	1·560
„	1898	Pineau Noir ..	11·25	7·82	27·50	1·610	1·600
„	1899	White ..	12·00	7 14	15·20	0·760	1·240
„	1899	Pineau Noir ..	12·50	8 16	19·40	0 890	1·400
„	1900	Pineau Meunier	11·00	8·16	18·60	0·980	1·650
„	1900	White ..	12·50	7·48	21·00	0 500	1 020
„	1901	„ ..	10·00	9 00	18·10	0·580	2·010
„	1901	„ ..	8·00	7·56	14·00	0·640	1 ·980
„	1901	Red	11·75	7·82	21·30	1·240	1·300
Whakapirau, Kaipara	1903	Shiraz ..	11·25	6·44	24·50	1·700	1·540
Ditto	1903	Verdeilho ..	14·50	6·25	22·60	0·610	1·300
„	1902	Shiraz ..	12·00	6·00	19·30	1·610	1·100
.. ..	1903	Isabella ..	13·00	6 90	15·00	1·500	1·400
.. ..	1904	„ ..	10·50	5·74	15·00	1·100	1·304
.. ..	1903	Red	10·00	8·00	14·20	1·900	0·800
Masterton, Wairarapa	1902	„	9·50	6·00	14·30	1·020	1·560
Waerenga Experimental Station, Waikato	1902	Cabernet ..	10·60	5·35	22·10	0·667	1·686
Ditto	1902	Shiraz ..	11·00	8·50	19·50	0·998	1·354

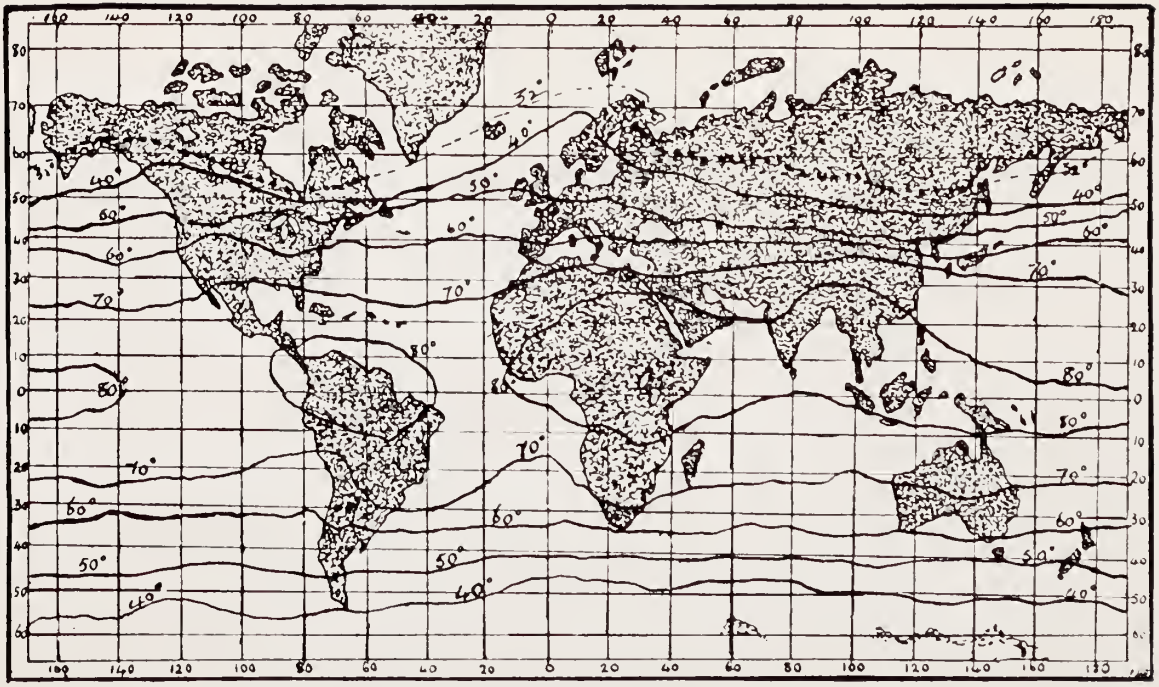
Place of Production.	Year of Vintage.	Name of Grape.	Chemical Composition of the Wine. Alcohol per 100. By Volume.	Per 1,000. Acidity as Tartaric Acid.	Extractive Matter.	Tannic Acid.	Bi-tartrate of Potash.
NEW ZEALAND—*continued.*							
Waerenga Experimental Station, Waikato	1902	Pineau Meunier	11·50	7·00	26·00	1·100	1·240
Ditto	1902	Verdeilho ..	12·50	6·00	24·00	0·500	1·410
„	1903	Cabernet ..	10·60	6·46	24·00	0·944	1·750
„	1903	Shiraz ..	9·75	7·48	19·10	0·513	1·620
„	1903	Pineau Meunier	11·50	6·80	22·00	0·716	1·200
.. ..	1903	White ..	12·25	6·00	20·30	0·118	2·100
„	1904	Chasselas ..	11·75	6·29	18·01	0·115	1·700
„	1904	White ..	11·50	6·12	21·40	0·112	2·311
„	1904	Cabernet ..	10·50	5·95	23·30	0·840	1·680
„	1904	Shiraz ..	10·80	6·46	21·60	0·590	1·520
„	1904	Pineau Meunier	12·00	5·78	25·10	0·730	1·328

By comparing the various components of the Florentine wines with those produced in New Zealand, readers will no doubt be impressed by the similarity in the proportions of their chemical constituents.

On page 1 are to be found the temperatures best suited to the production of wine-grapes. Below I give the temperatures of Auckland during the various stages of growth.*

Period.	Auckland. Deg.	Temperatures required. (See p. 1.) Deg.
Mean annual temperature for nineteen years ..	59·4	..
Mean temperature during the bursting of the buds	54·75	53–55
Mean temperature during blossoming and setting	65·75	64
Mean temperature from bursting of the buds to maturity	67·25	62–70
Mean temperature during last forty days ..	72·6	66 at least.

* For these and other meteorological statistics I have to acknowledge my indebtedness to Mr. T. F. Cheeseman, of the Auckland Museum, whose observations and records I have used for my information.—R. B.



Map of Isotherms, showing Countries with same Average Yearly Temperature.

Viticulture.

Hence Auckland approaches very closely the ideal temperature for the production of wine-grapes.

In the Hawke's Bay district the climate is equally well suited, and, as in the case of Auckland, compares very favourably with the standard laid down. I am indebted to Mr. A. Hamilton, of the Wellington Museum, for the following figures, showing the mean temperatures of the Hawke's Bay district over a period of fourteen years, and also for the figures relative to the mean rainfall for this district given on the next page.

	Deg.		Deg.
January	66·7	July	49·9
February	66·4	August	50·9
March	63·1	September	54·6
April	59·5	October	57·9
May	55·9	November	62·0
June	51·3	December	65·7

	Hawke's Bay Temperatures. Deg.	Temperatures required. (See p. 1.) Deg.
During bursting of the buds	57·9	53–55
During blossoming and setting	65·7	64
During period from bursting of buds to maturity	64·8	62–70
During the last forty days	66·6	66

From the map opposite we notice that the finest wines of Europe are produced in those countries lying between the isotherms of 55° and 65° in the Northern Hemisphere, and that New Zealand lies between the corresponding isotherms in the Southern Hemisphere.

Rainfall and Moisture.

In addition to temperature, an important factor in the production of grapes is the amount of rainfall, and the humidity of the atmosphere. It has been urged by some that the rainfall in New Zealand is excessive, and consequently detrimental to the growth of good wine-grapes: such is not the case, except possibly in Taranaki and the west coast of the South Island, where the rainfall is abnormal.

The average annual rainfall of Auckland, extending over a period of twenty-five years, is as follows:—

	Rainfall in Inches.		Rainfall in Inches.
January	2·54	August	4·24
February	3·57	September	3·19
March	2·48	October	3·53
April	3·19	November	2·88
May	4·18	December	2·75
June	4·86		
July	4·64	Total	42·02

The average rainfall of Hawke's Bay is as follows :—

	Rainfall in Inches.		Rainfall in Inches.
January	3·79	August	4·16
February	3·98	September	1·39
March	2·87	October	1·67
April	2·29	November	2·44
May	3·04	December	2·69
June	3·38		
July	3·06	Total	34·76

The mean annual rainfall throughout Italy is 1,200 mm , or 48 in. At Conegliano, whose wines have been immortalised by the poets, the average annual rainfall during the four years I was studying there was as follows : 1,476·2 mm., 1,226·8 mm., 1,058·05 mm., and 1,306·8 mm. ; or an average annual rainfall of 1,260 mm., equal to 50 in.

At the risk of wearying the reader with details and decimal points, I have given full comparisons, both as regards temperature and rainfall, between the climate of New Zealand and that of the wine-producing countries of Europe. I have also compared minutely the wines produced here with some of the most famous wines of Italy. This has been done to meet the frequently urged objection that the climate of New Zealand is unfavourable to the production of good wine. and to convince hesitating planters that the North Island of this country is endowed with a climate well suited to the production of high-class light wines ; and for the social well-being of the people these are the best class of wines for general use.

CHAPTER II.

SOILS.

Next to the influences of climate, dealt with in the preceding chapter, the most important consideration in the growth and development of the vine is the question of soil. The grape-vine is a very accommodating plant in this respect, and, while evincing its likes and dislikes, possesses a greater power of adapting itself to soil provided for it than any other plant. In fact, given a suitable climate, there is but little soil in the North Island of the colony where it will not flourish and bear fruit.

The properties of the soil, however, have a very important bearing on the wine produced, both in regard to quality and quantity.

For the purposes of consideration these properties may be classified under two headings—(1) The chemical composition of the soil : (2) the physical character, or consistency. In both classes there is a wide range of varia-

tion, from the hungry gum-land to rich loams, and from stiff tenacious clay to light pumice soils.

Deficiencies in the chemical composition of the soil are corrected by the addition of manures or fertilisers, whilst defects in the consistency are remedied by means of deep tillage in the preparation of the vineyard, drainage, frequent stirring of the land, paring and burning, and the addition of lime and manures.

Although, as mentioned above, the grape-vine flourishes in almost any soil, the economical result is dependent upon the existence in the soil of the proper plant-food necessary to the vine for the perfect production of its fruit. This must not be taken to mean that the richest soil will always yield the most profitable result, as, for instance, in the case of a vine planted in a rich loamy soil with an abundance of moisture. It will grow vigorously, the branches and foliage are produced luxuriantly, and it yields a heavy crop of large berries. This condition, however, does not result in the production of a good wine: it can be made only with great difficulty, and is hard to preserve in a good condition. On the other hand, grown in a light, poor, dry soil, the canes and leaves will be less luxuriant, the crop lighter, and the berries smaller, but the resulting wine will be of far higher quality, easier made, preserving better, and possessing a much finer colour and flavour.

Influence of the Soil.

We have noted in the previous chapter the great effect climate has upon the composition of the wine; the influence of different soils is even more pronounced. The table below shows the nature of the soils producing the most famous wines of Europe.

Wine.	Country.	Soil.
Lacrima Christi ..	Italy	Volcanic.
Capri	,, ...	,,
Chianti	,, ...	Limestone and marl.
Champagne . ..	France	Chalky
Bordeaux	,, ...	Quartz and gravelly.
Medoc	,, ...	,,
Hermitage	,, ...	Granitic loam.
Malaga	Spain	Clayey.
Tokay	Austria-Hungary ..	Basaltic.

In fact, so susceptible is the wine to the influences of the soil, that in adjoining vineyards the same variety of grape, given the same cultivation, will produce a wine with entirely different characteristics.

Distributed throughout New Zealand are an infinite variety of soils. In the northern districts the most common are loam, volcanic, gum-land, alluvial flats, limestone, sandy, and peaty soils. With the exception of the peaty and swampy lands, all these are well suited for wine-growing.

In Hawke's Bay there are thousands of acres of alluvial and gravelly loam, and in the vineyard there the grape grows to perfection, yielding a high-quality light wine.

That the gum-lands of the Auckland Province are adapted for grape-culture is shown in the success of the vineyards planted in this class of soil at Waerenga, Wade, Albany, Birkenhead, Waikumete, Henderson, Kaipara, Bay of Islands, &c.

The volcanic soils around Auckland, in the Lower Waikato, Whangarei, and Hokianga, and the limestone and sandstone soils of Whakapirau, in the Kaipara district, have all been tried with vines, and have proved their suitability.

CHAPTER III.

AMERICAN VINES.

Classification and Description.

The special value of the American vines lies in the power they possess of resisting the attacks of phylloxera. About forty years ago the vineyards of Europe were threatened with extinction by the insect. After many expensive but useless remedies had been tried, it was concluded that the only salvation from the ravages of the pest lay in the adoption of American vines as stocks. Since then they have been closely studied, experimented with, and severely tested, and, as the result of these trials, are now largely cultivated in all wine-growing countries.

Classification.

In all, eighteen species of these vines are found in their native home, the United States of America. They are as follow:—

V. rotundifolia.
V. Munsoniana.
V. labrusca.
V. californica.
V. caribaea.
V. candicans.
V. coriacea.
V. lincecumii.
V. bicolor.
V. aestivalis.
V. Berlandieri.
V. cordifolia.
V. cinerea.
V. rupestris.
V. monticola.
V. arizonica.
V. riparia.
V. rubra.

Description.

V. rotundifolia. | *V. Munsoniana.* Neither of these varieties are of any practical utility to growers.

V. labrusca.

Numerous varieties of this species have been obtained from seeds; they display but little resistance to phylloxera, and are, in consequence, of no value in the vineyard. A well-known variety in this species is the Isabella, which has been extensively planted in this country. It yields a large crop of fruit, but the wine produced is of a fair quality only, and the low power of resistance shown by the Isabella renders its presence in the vineyard highly undesirable.

V. aestivalis.
V. bicolor.
V. lincecumii.
V. candicans.
V. coriacea.
V. caribaea.
V. californica.

These species are of no value as stocks, and possess no special adaptability.

V. Berlandieri.
V. cordifolia.
V. cinerea.

V. Berlandieri.

Characteristics.—Roots strong, stem of medium thickness, the new wood showing seven pronounced ridges running along it: so marked are these ribs that a cross-section presents a star-like appearance. The bark on the new canes is smooth, and of a deep-cinnamon colour. The buds are fairly prominent, and widely spaced. The tendrils are unevenly distributed, short, and thin. The leaves, medium-sized to small, differing in the numerous varieties, dark-green and glossy on the face, the backs of a light-green colour, the veins covered with short hair; the shape of the leaves is roundish, tapering to a point; the edge of the leaf is lightly indented, often curling back. The bunch is medium-sized and compact; the berries small and round, of a black colour, with a heavy bloom: the juice free from any unpleasant flavour.

These characteristics are strongly marked in some kinds of the Berlandieri, but are subject to variations, which are divided into two classes—(1) Tomentose: These have been discarded on account of their lack of adaptability to calcareous soils; they are distinguished by the thick matted hair on the young shoots and on the backs of the leaves, which are usually dull and thin. (2) The second and most valuable class is the Glabra. These are almost free from hair, and possess a marked liking for soils rich in lime, where other American vines are subject to chlorosis.

By means of seeds and cuttings many valuable varieties of the Berlandieri have been obtained, those best adapted for this country being the Berlandieri Ressenguier No. 1 and No. 2. In all soils containing a high proportion of lime they flourish vigorously, and are extremely hardy.

The Berlandieri is a native of Texas, where it grows wild in soils containing as much as 96 per cent. of carbonate of lime, and in a climate varying from 110° in the summer to below zero in the winter. It has been largely used in replanting the vineyards destroyed by the phylloxera in Champagne, where the soil in parts contains 75 per cent. of chalk.

The Berlandieri is propagated by means of cuttings (see Chapter VII.), and possesses a strong affinity for the European varieties, the graft knitting well and growing vigorously.

In addition to the Berlandieri, among these species are to be found the *V. cordifolia* and the *V. cinerea.* These are highly resistant to phylloxera, but, owing to the difficulty of propagating them by ordinary means, and the lack of any special adaptability to calcareous soils, they are much inferior to the Rupestris and Riparia.

V. rupestris.
V. monticola.
V. arizonica.

V. rupestris.

This variety is, in certain soils, the most valuable of the American vines at the disposal of the vigneron. Its appearance is so unlike any other of

the American vines as to render it easily distinguishable. It presents a bushy appearance, with numerous strong shoots growing evenly from all parts of the short, thick trunk. The new canes are lightly ribbed, with a smooth or shining surface of a chestnut-brown colour. The tendrils are irregularly distributed. The young shoots appear early, and whilst young are of a deep-purple colour, showing numerous fruit-bunches of a redder hue. The leaves are wider than they are long, sharp-pointed, varying in size, but always small; in appearance not unlike those of the apricot after summer pinching. The edge of the leaf is serrated or saw-like, often curling inwards throughout its length. In colour, bright-green on the face, of a lighter tint on the back. Fruit, small bunches and small berries, which produce a very highly coloured juice.

In its native state the Rupestris is found widely distributed over Missouri, Arkansas, Texas, New Mexico, and Indian Territory; flourishing on rocky, broken land, in exposed positions, in siliceous gravelly soil; subject to extremes of temperature, with a high scorching heat in summer and intense cold in winter. Its native habits cause it to be an invaluable stock for planting in poor soils.

A large number of varieties of the Rupestris have been obtained, those with a vigorous growth being naturally the best. Their resistant power to phylloxera and their affinity for the European scions render them well known and highly appreciated in those districts possessing a dry climate and poor siliceous soils.

Among the best known varieties of the Rupestris are the Rupestris Mission, and the Rupestris du Lot, otherwise called the Rupestris Monticola or Phenomene. Others of great value are the Rupestris Martin, Rupestris Metallica, Rupestris Ganzin, Rupestris Fortworth, &c.

The *V. monticola* is of no practical use, but the *V. arizonica*, although not well known as yet, possesses a fair power of resistance, a good affinity for European scions, and is easily propagated from cuttings. According to Professor Cavazza the Arizonica is preferable to the Riparia in dry or stony localities.

V. riparia.
V. rubra.

The last-named is of no importance as a stock, but the other in this series, the *V. riparia*, is one of the most useful of the American vines, whether for replanting phylloxera-infested vineyards or laying out new ones.

V. riparia.

Characteristics.—The trunk is above medium-sized, with a vigorous growth. The canes are thin, with the buds widely spaced, the bark on the ripe wood varying from red to a grey colour. The tendrils are unevenly distributed. The leaves are long and divided into five distinct lobes, each ending in a long point; the edge of the leaf is sharply serrated, the surface of a dark-green colour on the face, and light-green on the back. Both bunches and berries are small, producing a rough astringent juice. The Riparia is found growing wild over the greater part of the United States, extending even into Canada. In this widely distributed area it flourishes vigorously, displaying an immunity and indifference to climatic influences.

As a stock it is one of the most highly resistant to phylloxera, and is easily propagated from cuttings. It adapts itself well to varying soils, flourishing best in rich alluvial loams, or in volcanic land, and showing a strong affinity for the European varieties. Numerous varieties of the *V.*

riparia have been raised, mostly from seeds, and, as in the case of the Berlandieri, may be divided into two classes—(1) Glabra, (2) Tomentose.

The best known in the first class are the Riparia Gloire de Montpellier (otherwise known as the Riparia Portalis, Riparia Michel, or Riparia Saporta) and the Riparia Grand Glabre. Among the Tomentose the most useful are the Riparia Gigante du Mas de las Sorres and the Riparia Violetta. The whole of the Riparias are best suited to rich, fertile soils which do not contain more than 15 to 20 per cent. of lime. It was formerly thought that the Tomentose class were less adaptable to calcareous soils than the Glabra, but recent observations by Ravaz have demonstrated that such is not the case, provided the above-mentioned limits are not exceeded. It has been found that there is but little difference in the resistant powers of the numerous varieties, the most useful being those showing the most vigorous growth and possessing the largest leaves.

Conclusions.

From the foregoing descriptions of the pure varieties of American vines we note that a large number have been cultivated and tested both in Europe and America. As the result of these trials, extending over many years, and in different soils and climates, the majority have been discarded or relegated to collections and experimental growers, the only ones of the pure varieties left for the practical grower being the Berlandieri for limestone soils and those rich in lime, the Rupestris for siliceous, sandy, stony, and the poorer soils, and the Riparia for siliceous, or lightly calcareous, deep, rich, and fertile ones.

CHAPTER IV.

AMERICAN VINES

Hybrids.

The pure species mentioned in the foregoing chapter do not, however, represent the whole of the phylloxera-resistant stocks at the disposal of the grower. There are also the hybrids. These have been obtained, both naturally and artificially, by crossing the American vines between themselves or with European varieties.

The work of hybridization or crossing has been carried on by experimentalists, both in America and Europe, and has placed many valuable vines in the hands of the vigneron. The size and scope of this book prevents me going fully into the work of hybridization: those interested will find many valuable works specially devoted to the subject.

Briefly stated, hybrids are obtained as follows: the female flowers of one variety are fertilised artificially by applying the pollen, or fertilising agency, of the male flowers of another variety. The seeds from the fruit produced by this cross are then raised, and the seedling is known as a hybrid.

The object of the above operation is to secure in a single variety a combination of the good points of both the pure varieties thus brought together,

or the elimination, in the hybrid produced, of some of the weak points or faults of the parent species.

We have already noted that the fruit borne by the American vine is of a very inferior sort, but they possess a very high resistant power to phylloxera. In the European varieties the opposite occurs: the vines show no resistance to phylloxera, but produce a perfect fruit. It was thought by some viticulturists that by fertilising the American vine with the European the hybrids resulting might resemble the European variety in its fruiting powers, and at the same time display the resistance to phylloxera shown by its American parent. Could this have been done it would have conferred a great boon on growers, as it would have done away with the necessity for grafting. So far, however, while these experiments have given us many useful hybrids, valuable as stocks, and which show great affinity and adaptability, the ideal vine—the direct producer—still remains a pious hope, perhaps some day to be realised.

A curious result of the researches in hybridization was the discovery of the fact that the hybrid invariably resembles the variety from which the pollen was taken—that is to say, the vine bearing the male flower. Thus, in a cross between the European and American varieties, where the pollen of the American vine has been used to fertilise the flower of the European, the cross produced has shown great phylloxera-resistant powers, but has fruited only poorly. Where the fertilising agency has been taken from the European vine and crossed into the American, the seedling which resulted showed the reverse features: it was a good fruit-bearer, but its powers of resistance were small.

Americo-American Hybrids.

While, however, the search for the vine which will resist phylloxera and at the same time produce good fruit has so far proved abortive, many valuable hybrids have been raised by crossing the American vines among themselves, with the object of securing better stocks. In many instances these hybrids have been produced naturally through the agencies of insects, or by vines of the different varieties having become entwined, the pollen of one has fallen on to the flowers of another variety and so fertilised them.

Among the numerous Americo-American hybrids which have been tested, the most valuable and useful are those mentioned below:—

(1.) *Solonis.*

A natural hybrid from three varieties: Candicans x Riparia x Rupestris, and found growing wild on the banks of the Red River, North Texas. It possesses a unique appearance, and once seen is easily remembered. It throws a luxurious foliage, the lobes of the leaf showing the peculiarly curved teeth of this hybrid. It grows well in soils not too highly calcareous, and is particularly adapted to rich soils containing plenty of moisture. It is easily propagated by means of cuttings, and displays a strong affinity for the European varieties.

(2.) *Riparia* × *Rupestris.*

The Riparia-Rupestris hybrid, like the Solonis, is a natural cross, found growing wild in America. It has also been produced artificially in France by Millardet and de Grasset.

The best known of these hybrids are No. 101[14] and No. 108, and Nos. 3306 and 3309. They all possess a high degree of resistance, and are very adaptable to all soils not excessively calcareous, flourishing where the pure Riparia or Rupestris would be attacked by chlorosis.

European-American Hybrids.

As mentioned in the beginning of this chapter, numerous crosses have been made with European and American vines with the object of procuring a "direct producer," and while, as already remarked, this aim has not been successful, many of the hybrids thus procured possess useful qualities as stocks. The following are the most popular :—

Vinifera × *Berlandieri.*

These are well adapted for soils containing an excess of lime—a property derived from the American parent. The most important of these hybrids are the Cabernet x Berlandieri and the Chasselas x Berlandieri.

Vinifera × *Rupestris.*

These hybrids display a vigorous growth, high resistance, and a fair amount of adaptability to varying soils. They are easy of propagation from cuttings, and possess a marked affinity for the European scions. Consequently they have been largely used as stocks. The best known are the Aramon x Rupestris (Ganzin No. 1 and No. 2), well adapted for soils containing as much as 40 per cent. of lime; Gamay Couderc, or Colombeau x Rupestris 3103; Mourvedre x Rupestris 1202 (Couderc); Bourrisquou x Rupestris Martin; and Cabernet x Rupestris 33.

Vinifera × *Riparia.*

These hybrids resist chlorosis better than the above. The most important are—Aramon x Riparia 143 (Millardet and de Grasset) and Alicante-Bouschet x Riparia 141.

CHAPTER V.

AMERICAN VINES.

Power of Resistance to Phylloxera.

The American vines and their hybrids have been divided into three classes by Millardet according to their power of resistance to phylloxera—(1) Absolute resistance; (2) partial resistance; and (3) no resistance.

Absolute Resistance.—In the first class he placed those varieties which showed entire resistance, and were not affected in any degree when planted in phylloxera-infected soils.

Partial Resistance.—In this class are placed those vines offering a certain amount of resistance, but which were liable to perish when attacked under varying conditions.

No Resistance.—This class includes all those kinds which are unable to resist the phylloxera, and cannot be attacked by the insect without perishing.

Viala and Ravaz have, in their latest work, drawn up the following scale, which shows the degree of resistance possessed by the different vines. Absolute immunity is calculated at 20 points, whilst absence of resistant power is reckoned as 0 points. The *V. rotundifolia* occupies the premier position for resistance, with 19 points. This may be taken for all practical purposes as representing absolute resistance. At the bottom of the table will be noted the European varieties, these showing no resistance whatever to the ravages of the insect.

Scale of Resistance (Absolute Immunity, 20 points).

Name of Vine.	Resistant-power.
Rotundifolia	19
Riparia Rupestris Cordifolia	18
Riparia x Rupestris Cordifolia x Rupestris Berlandieri Monticola Riparia x Berlandieri Riparia x Monticola Rupestris x Berlandieri	17
Rupestris du Lot Rupestris de Lezignan Cinerea x Rupestris Riparia x Aestivalis	16
Cinerea Aestivalis Candicans	15
Viala Solonis Novo Mexicana Noah	14
Taylor and Michigan	13
Jacquez and Herbemont	12
York-Madeira	11
Elvira	10
Isabella	5
European Varieties	0

These resistance figures must not be taken in an absolute sense, as they are affected by climate, soil, cultivation, and grafting. In a hot, dry climate, for instance, the phylloxera is more deadly than in a cold, moist one. Stocks like the York-Madeira with a resistance of 11, and the Solonis with 14, will flourish despite the phylloxera in cool climates, but perish if attacked in hot, arid districts. At the same time, the majority of American vines are affected but little by temperature—a property acquired in its wild state, where it is subjected to wide extremes of climate.

The nature of the soil and the cultivation given to the vine also affect the power of resistance, the vigorous growth it attains in rich, well-cultivated soils assisting it to resist the ravages of the disease.

With regard to the influence of the graft upon the stock, Couderc, at a congress held in Lyons in 1894, referred to the fact that the American vines are, in many instances, susceptible to the influences of the scion, some scions

increasing the power of the stock, others weakening it. In support of this argument he gave the following table :*—

Scion.	Stock. Riparia Glabra. Resistance 19.	Riparia Tomentose. Resistance 19.	Rupestris. Resistance 19.	Solonis. Resistance 15.	York-Madeira. Resistance 11.
Aramon	12	17	19	20	5
Carignane	17	18	20	16	7
Cinsaut	9	17	19	15	3
Alicante-Bouschet ..	17	16	20	14	7
Petit-Bouschet ..	18	20	20	20	6
Clairette Blanche ..	20	20	20	12	13
La Folle	17	18	19	18	8
Pinot	13	18	14	19	9
Cabernet Franc ..	20	20	20	20	17
Cabernet Sauvignon ..	20	20	20	18	13
Syrah (Shiraz) ..	20	20	18	20	13
Gamay	12	14	16	16	2
Terret Bouschet ..	14	15	20	15	6

Thus we notice that the York-Madeira, which, according to Couderc, possesses a resistance of 11 when grown ungrafted, has its resistant-power increased to 17 when grafted with the Cabernet Franc, but it is reduced to 2 when grafted with the Gamay. Many other striking instances are noticeable ; but it will be observed that the resistant-power is weakened in but few cases, whereas in numerous examples the power is increased.

Experiments and observations are still being carried on with the object of gaining further knowledge upon this important question.

CHAPTER VI.

AMERICAN VINES.

Adaptability to Different Soils.

We have dealt in the preceding chapter with the influence of the climate upon the different American vines, and also with the effect produced by the various European scions when grafted upon the American stocks. A more important factor than these, affecting both the resistant-power and growth of the vine, is the soil.

The soil, so far as American vines are concerned, may be divided into two kinds—(1) Those containing lime in small quantities ; (2) those containing

* It will be noted that Couderc gives the American vines a slightly higher resistant power all round than Viala and Ravaz do in the table on page 14.

an excess of lime. Strictly speaking, the term "lime" can only be applied accurately to burnt limestone or shells, but it is used here in its broad sense to include all varieties of carbonate of lime, such as limestone, chalk, shells, marl, &c. In fact, limestone, chalk, marble, and oyster-shell are all composed of the same substance in a different form.

Those soils which contain only a small quantity of lime may, as already stated, be divided into rich, deep, fertile soils, where the Riparia should be planted; light, sandy, dry soils, for which the Rupestris is the most suitable; and wet, humid soils, where the Solonis is best adapted. These soils have been termed "easy" by Racah, as the vine easily adapts itself to them, and is not affected by chlorosis.

Those soils of a compact, calcareous, humid, or arid nature, where the Riparia grows only slowly or perishes, are termed "difficult," and have been tabulated by Racah, as follows :—

Kind of Soil.	Condition.	Variety of Stocks best suited to Difficult Soils.
Calcareous	Sweet, moist, and friable	*Mourvedre* x *Rupestris No.* 1202. For calcareous clays, and siliceous-calcareous soils of a deep fertile nature. It will stand as much as 60 per cent. of lime, and is considered in France to be the best stock for these soils. It displays a strong affinity for all European scions.
	Medium ditto ..	*Aramon* x *Rupestris No.* 1. Is better adapted for shallower soils than the above, tolerates 40 per cent. of lime, and has a strong affinity for European varieties.
	Dry	*Berlandieri* x *Riparia* 420A. For shallow, dry soils. Is a useful stock for table-grapes on account of the evenness with which the fruit ripen upon it, and is preferable to the pure Berlandieri, as it is more easily propagated from cuttings.
Tenacious	Sweet and moist	*Aramon* x *Rupestris No.* 1. Excellent for yellow clay. *Solonis* x *Riparia* 1616. Grows well in moist soils, European scions yielding heavy crops on it.
	Dry ..	*Riparia* x *Cordifolia* x *Rupestris* 106[8]. Preferable even to Rupestris du Lot in hard, stiff, dry soils, in which it grows vigorously. It is well adapted to blue clay. *Rupestris du Lot.* Stands fair amount of dryness, but should not be grafted with shy-setting varieties, as it increases this tendency.
Dry	Shallow ..	*Berlandieri* x *Riparia* 420A.
	Deep ..	*Rupestris du Lot.* *Riparia* x *Rupestris* 3309.
Wet ..	..	*Mourvedre Rupestris.* *Aramon Rupestris.* *Solonis* x *Riparia* 1616.

CHLOROSIS.

This disease, already briefly referred to in the foregoing chapters, corresponds in grape-vines to a disease of the same name in human beings—chlorosis, or anæmia.

Symptoms.

It appears first of all upon the leaves of the diseased vine. The green colour assumes a yellowish tinge, and gradually becomes a bright yellow; in time this yellow fades, and the leaves become a creamy white, and finally die and drop off. The young shoots also become yellow, with small semi-transparent leaves, the extremities gradually wither and die, and the vine perishes.

If the vine is attacked before blossoming, the flowers do not set; and if attacked after setting, the berries remain small, and, instead of swelling, perish and drop off.

Causes.

Chlorosis is caused by the presence in the soil of an excess of carbonate of lime. Ordinarily, the carbonate is insoluble and is not absorbed by the roots of the vine. The rain-water, however, contains minute quantities of carbonic-acid gas. This dissolves the carbonate of lime in the soil, and renders it capable of being assimilated by the vine. The soluble lime absorbed by the roots passes into the system of the vine, and, coming in contact with the sap of the cells, neutralises the natural acidity of the sap, producing the symptoms described above.

The disease varies in intensity, and is affected by the amount of lime contained in the soil, the amount of moisture present, and the manuring and cultivation it receives. Chlorosis is also influenced to a certain extent by the condition of the lime in the soil. Thus, where the lime is hard and in lumps, the disease is less pronounced than where the lime exists in a soft condition or as a fine powder. Excess of moisture increases the intensity of the chlorosis, as, of course, it affords more soluble lime for the roots of the vine, consequently the disease is less prevalent in dry summers than in wet ones.

There is no positive cure for this disease. The only remedy is to plant stocks which resist it. In some places, however, the appearance of the disease may be prevented by careful cultivation of the land. For instance, where the subsoil is calcareous, it should not be disturbed or brought to the surface. Manuring with unfermented stable-manure should always be avoided where there is any tendency to this disease. If applied green, the manure decomposes in the soil, and in the process carbonic-acid gas is given off. This, combining with the moisture in the soil, dissolves the carbonate of lime present, and it is absorbed by the vine.

The following table, showing the resistance offered to chlorosis by the different stocks, has been drawn up by Viala :—

Resistance to Chlorosis.

Order of Resistance.	Pure American Vines.	Americo-American Hybrids.	European-American Hybrids.
1	*V. Berlandieri* ..	Monticola x Berlandieri ..	Vinifera x Berlandieri.
2	*V. monticola* ..	Berlandieri x Riparia ..	Vinifera x Monticola.
3	*V. riparia* ..	Rupestris x Berlandieri ..	Vinifera x Riparia.
4	*V. rupestris* ..	Candicans x Berlandieri..	Vinifera x Rupestris.
5	*V. arizonica* ..	Solonis	Jacquez.
6	*V. californica* ..	Rupestris x Arizonica ..	Vinifera x Cordifolia.
7	*V. candicans* ..	Rupestris x Californica ..	Vinifera x Cinerea.

CONCLUSIONS.

We have now fully studied all the different phases of the American vines and their hybrids. We have noted their characteristics and distinguishing features, and have seen how they vary in the resistance they offer to phylloxera under different conditions, and the degree in which the resistant-power is affected by the influence of the European scion. Finally, we have remarked on those varieties which offer the greatest resistance to chlorosis in soils which contain an excess of calcareous matter.

To aid the practical grower in his selection from the numerous stocks mentioned, I will conclude this part by giving in a tabular form the names of those varieties of most use in the different soils of this country—(1) For those soils which are not calcareous (*i.e.*, do not contain an excess of lime); and (2) for calcareous soils, or those containing an excess.

Variety.	Best Sort.	Condition of Soil.
	For Non-calcareous Soils.	
V. riparia ..	Gloire de Montpellier Grande Glabre	Deep, rich, loose.
V. rupestris ..	Rupestris Martin ..	Dry and gravelly.
	Rupestris du Lot ..	Siliceous and schistose clays.
V. rupestris ..	Mourvedre Rupestris ..	Gum-land and stiff tenacious clays.
	For Calcareous Soils.	
Riparia x *Rupestris*	Couderc 3309	Lightly calcareous.
	Couderc 3306	,,
	Millardet 101[14] ..	,,
V. rupestris ..	Rupestris du Lot ..	,,
	Mourvedre Rupestris ..	,,
V. Berlandieri ..	Berlandieri	Strongly calcareous.
	Chasselas x Berlandieri No. 41	Strongly calcareous (where the Solonis turns yellow).

CHAPTER VII.

PROPAGATION OF AMERICAN VINES.

Nursery-work.

I would advise all grape-growers, and those who intend planting outdoor grapes, not to plant out the cuttings direct into the permanent vineyard. Some of the American vines are propagated only with difficulty, and serious loss would result if they are planted out before being rooted in the nursery.

To avoid loss of time, labour, expense, and disappointment following a number of misses, it is advisable to prepare a nursery for the purposes of propagating and grafting. This allows of the cuttings and grafts being concentrated in a small area, where they are easier managed and under better control than when spread over a larger tract of land in the widely planted vineyard.

Site and Preparation of Nursery.

The position of the nursery should be near that of the proposed vineyard if possible, and the best piece of land available should be selected. The following are the chief points for consideration in the selection of the site for a nursery: (1) The soil should be deep, rich, loose, and fertile, care being taken to make sure that it is well drained; (2) the aspect should be north-easterly, warm, well-sheltered from the cold winds, and free from late frost in the spring.

The soil of the nursery must be well cultivated before planting; in ordinary good, loose soils it should be trenched to a depth of 18 in. The subsoil should be brought to the surface and exposed to the sun and weather, whilst the land should be improved by the addition of well-rotted manures, leaf-mould, sand, and other good rooting-mediums.

The main object to be kept in view in the preparation of the nursery is to secure a medium, loose, well-drained soil. This assists the cuttings by allowing them to root freely, and at the same time provides a soil sufficiently rich in plant-food to keep the young vine well nourished.

Unfortunately, in many districts it is impossible to make the nursery anywhere except in clay soils. These, on account of their compact nature, retard the free development of the tender new roots, and the cuttings fail to strike or grow very weakly. Still, with proper preparation, a good nursery may be secured even on clay land. First of all, it must be trenched to a depth of 2 ft. or 3 ft. some months before planting. If the clay is very stiff and tenacious, it will be greatly improved by burning it in heaps, afterwards scattering them and working it into the land again. A dressing of slaked lime, at the rate of 3 or 4 tons to the acre, is advisable, and the soil generally improved by the addition of well-rotted manures, sand, &c.

In every case the nursery must be properly and efficiently drained. Ill-drained soils are always cold; the excess of water in the land slowly evaporates into the air. This means that the sun's heat is absorbed in converting the moisture of the soil into vapour, instead of warming the land and assisting the growth of the plants. Hence the necessity in most soils for artificial drainage. This is best done by means of tile drains, but

where tiles cannot be procured drains may be opened up and partially filled in with large lumps of metal, on the top of which small stones should be placed to prevent the soil washing through. Care must, of course, be taken that all drains are laid below the depth to which the land is trenched. The nursery should be laid out in beds. These are better on a level if the nursery needs irrigation at any time; if, however, the land does not require irrigating, the beds should be raised.

The roadways and paths around the nursery beds should be lower than the cultivated land, and furnished with small side drains for the removal of the surplus water when irrigation is resorted to.

METHODS OF PROPAGATION.

The ground for the nursery having been selected and properly prepared, the question to be settled is the best method of propagation.

From Seeds.

The simplest and most natural method of propagating the vine is by sowing the seeds obtained from the ripe fruit of the selected variety. Unfortunately, the seedlings thus raised often vary greatly from the parent plant. More especially is this noticeable in the case of hybrids, and consequently this method is useless for the practical grower, although it affords an interesting field for experimentalists, as most of the new varieties are obtained from seeds.

From Cuttings.

The most common method of propagating and multiplying the different varieties of vines is by means of cuttings. To obtain the best results by this system the cuttings should be carefully selected from the healthiest and most vigorous vines, and on no account taken from weak ones nor those affected with chlorosis or any other disease. The wood should be clean and well ripened, with the buds close together, the portion nearest to the trunk being the best.

As the cuttings are usually planted some time after being selected and removed from the parent plant, it is essential they should be carefully preserved during the period between the taking of the cuttings and planting them out. By doing so the sap and moisture is conserved, and the vitality of the cutting retained.

For this purpose a dry spot should be selected, and a pit dug about 18 in. or 2 ft. deep, varying in size according to the number of cuttings to be preserved. The bottom of the pit should be lightly watered, the cuttings tied up in bundles of fifty, laid lengthwise in the pit, and covered in with dry soil. When required for planting they must be dug up with great care, only removing the quantity required for immediate use. By this method and the exercise of the precautions mentioned, the cuttings may be preserved in a good condition for several months.

In the case of cuttings coming from a long distance, it is advisable to soak them for two days in running water, or water frequently changed, before pitting them.

Most of the American vines, such as the Riparia, Rupestris, &c., are easily propagated from cuttings; but a few, like the Berlandieri, for instance,

are shy in rooting. To remedy this tendency, some recommend that those vines which are difficult to strike from cuttings should be pruned in the spring after the bursting of the buds, and when the young shoots are about ¾ in. long. The buds should be removed with a sharp knife, and the cuttings planted at once. By keeping the soil in a moist condition upwards of 75 per cent. of successful strikings may be obtained.

Montoneri Method.

An easy method of propagating the Berlandieri from cuttings is that advocated by Dr. Montoneri. This method consists of preparing the cuttings early, the "mother-plant" being pruned in the early autumn before the fall of the leaves. To prepare the cuttings, remove all the buds from that part of the cutting which goes below the ground. They should then be pitted in the manner described in the beginning of this chapter, and kept until the time of planting. They should be planted in the early spring; but, before planting, the bottom end of the cutting should be split and lacerated, and the bark between the buds scraped with a grater until the inner green bark is exposed. The cuttings should then be planted firmly in the soil. Dr. Montoneri states that the Berlandieri Resseguier No. 1 and No. 2 cuttings planted by this method gave a very high percentage of strikings, better even than the Rupestris du Lot and the Riparia, and in proof of this he gave the following results which had been obtained by him:—

	Number Planted.	Successful Strikings.	Per Cent.
Berlandieri Ressenguier No. 1 ..	6,360	4,075	64
„ No. 2 ..	2,800	2,300	82

Length of Cuttings.

The length of cuttings is an important matter. No hard-and-fast rule can be laid down, and it is advisable to vary the length according to the nature and condition of the soil. In loose, friable, dry, or sandy soils it is necessary, in order to provide the cuttings with sufficient moisture, to plant them from 10 in. to 14 in. long. In clayey, stiff, tenacious, or wet soils so much length is not desirable, and 9 in. is quite long enough.

It will be noted in general practice that the shorter cuttings possess more vigour and flourish better than the longer ones.

Time of planting Cuttings.

In most districts of New Zealand it is wise to defer the planting of cuttings until the late spring, when the buds are swelling and bursting, and the ground possesses sufficient warmth for the development of the young roots. If the cuttings are planted earlier than this they are liable to break in a weak and sickly fashion. This is due to the fact that the upper bud, which is above ground, finds itself in a warmer temperature than the lower or inferior bud underground. This results in the upper bud breaking into leaf before the lower bud has burst and begun to send out roots. The consequence is the upper bud bursts and commences to grow, finding its nourishment in the sap of the cutting; when this small supply is exhausted there is no further food available, and the shoot withers and dies.

To avoid this I strongly advise planting in the late spring. If the cuttings in the pit show signs of bursting buds, the grower need not become alarmed; all that is necessary is to remove the shoots with a sharp knife before planting.

Planting the Cuttings.

The ground having been trenched and manured as advised in the preparation of the nursery, a furrow or drill about 8 in. deep is opened up. This may be done with the spade in small nurseries, or in larger ones by means of an ordinary plough, or, better still, with the double mouldboard plough used for opening up potato drills. The drills or furrows should not be less than the depth advised, and the rows should be 3 ft. apart.

The cutting is placed against the side of the furrow, one bud being left exposed just above the level of the ground. The cuttings are then earthed over and the soil gently firmed with the foot. Afterwards, the bud exposed should be lightly covered with light soil or sand; this keeps it moist, and protects it from extreme heat and cold. The cuttings should be planted in a vertical position, and about 6 in. apart.

I have noticed in this country the practice of planting cuttings lengthwise or horizontally: this method is strongly condemned by experienced growers, as, although more shoots may be obtained from each cutting by this means, they are much weaker, and the ultimate result is a loss to the grower. One cutting for one future plant should be the grower's aim.

In light, well-cultivated soils cuttings may be planted by dibbling instead of opening up drills. In this method a hole is dibbled the length of the cutting; one man is employed in dibbling the holes, while a second plants the cuttings in them, and fills in around the cuttings with good top soil. A crowbar or dibble is then inserted into the soil near the cutting in an angular direction, and pressed down until its point reaches near the bottom of the cutting. The crowbar is then raised to an upright position alongside the cutting, thus packing it firmly around with soil. The operation is easily understood by a glance at Fig. 1A.

The subsequent care of the cuttings is mostly a matter of hoeing, weeding, and stirring of the soil. In the event of the land becoming very dry, irrigation or watering must be resorted to.

LAYERING.

Layering may be done in the winter or late spring. In the first case, a cane is layered as shown in Fig. 1., leaving one or two buds at the extremity above the soil. When rooted, the shoot is removed from the "mother-plant."

If layering is performed in the late spring, one or more green shoots are selected and layered, care being taken to keep the lateral shoots above the soil. When rooted, the shoots are separated, and removed the following winter. (See Fig. 16.)

These methods of propagation are used in the case of those vines like the Berlandieri, which are difficult of propagation from cuttings.

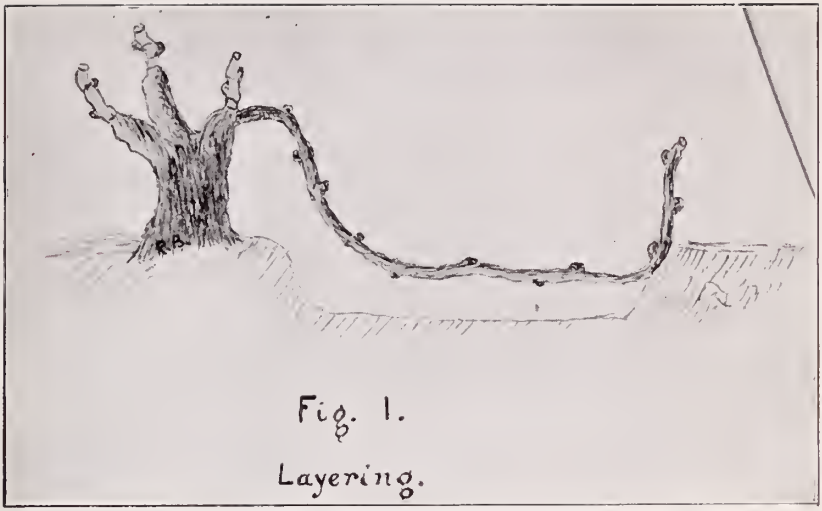


Fig. 1.

Layering.

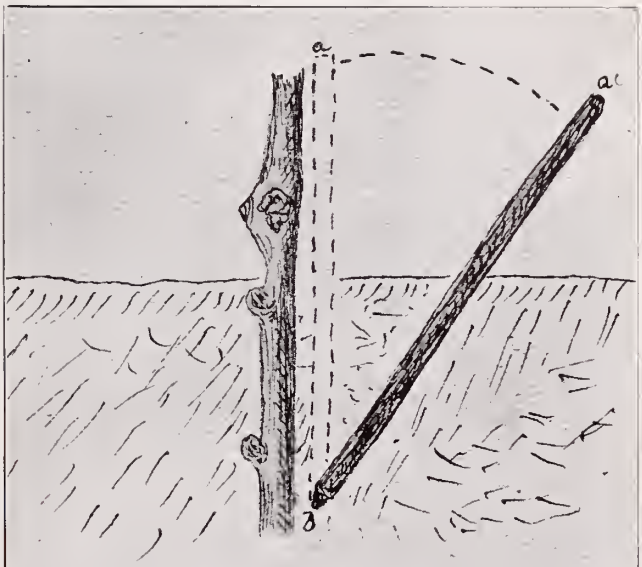


Fig. 1A. Use of a crowbar or lever in planting cuttings.

CHAPTER VIII.

GRAFTING.

The practice of grafting is a very ancient one. We even find it mentioned so far back as 300 B.C., and frequently referred to in the old classic authors. Modern grafting is, of course, widely different from the ancient methods, but the principle is the same.

Grafting was not applied extensively to the grape-vine until the outbreak of phylloxera, and the subsequent wholesale destruction of vineyards which followed.

The operation is not a difficult one, and only requires ordinary skill and intelligence on the part of the grower.

Theory of Grafting.

Grafting is the operation of removing a bud or scion from one variety and placing it in contact with the wood of another variety, which is to be used as the stock. At the points where the scion and stock meet a growth appears, which is known as the callus. This gradually spreads until it meets and unites. The sap then flows between the stock and the scion, and the grafting is completed. The result of the operation is that the buds, leaves, blossoms, and fruit of the scion are nourished by the sap and roots of another grape; whilst the roots of the stock are developed by the leaves of the scion.

The essential condition for success in grafting is the complete and even contact of the surface of the scion with that of the stock, and care must be taken to bring the cambium or generative layers of the scion in close touch with those of the stock. The other conditions necessary for a good and rapid union of stock and scion are a right temperature, a certain amount of moisture, and the free access of air. If the temperature is too low the vigour of the stock is impaired, and either failure results or the growth of the scion is weak. On the other hand, if the temperature is too high the scion dries up before the union is completed, whilst sudden changes of temperature are always dangerous. The growth of the uniting tissue is assisted by the presence of fresh air, and if the junction is constantly wet the free access of air is impeded and the respiration of the new tissue hampered.

Affinity.

We have already remarked that the physiological condition of the grafted vine is abnormal. We have two plants of the same species, it is true, but they differ widely in their habits and characteristics. The one a wild, uncultivated variety from the plains, forests, and mountains of America; the other the result of a thousand years of careful selection, crossing, and cultivation in Europe. These two are, as it were, made one, and they become absolutely dependent on one another for their very existence. It must be obvious to the reader that for this union to become a complete success the two must be, as the French say, "*en rapport*," or, as nearly as the English language describes it, they must display a marked affinity for each other.

Affinity may be described as a complex relation between the tissue or protoplasm of the scion and that of the stock. Where the relation is a harmonious one, and the two show a liking for each other, the union is soon

complete and both flourish. The roots of the stock develop indifferent to the louse so dreaded by its scion; the scion flourishing vigorously and bearing fruit abundantly, undisturbed by the fact that it is being nourished by a foreigner and an alien. In other cases, where the affinity is weak or absent, neither prosper, and both are subject to disease and even death. Others, again, after displaying an apparent liking for each other for some years, suddenly fail to agree, and the union is dissolved.

The varying degree of affinity between the various stocks and scions can only be determined by years of careful experiments and patient observation, and growers should not plant the American vines and graft them indiscriminately.

Recognising the inability of the ordinary grower to carry out these studies in a scientific manner, the Viticultural Division of the Department of Agriculture is carrying out a series of experiments at the Waerenga State Experimental Farm in the Waikato, and at the Experimental Station, Arataki, in the Hawke's Bay district.

Tools required.

No elaborate tools are necessary for the purpose of grafting: the only ones required are a wedge-knife (Fig. 2) for splitting the stocks and keeping the wedge open for cleft-grafting on old vines, a pair of secateurs (Fig. 3A), a saw (Fig. 2A), and grafting-knives (Figs. 3 and 4).

For binding the grafts the use of raffia is strongly recommended. It can be procured from any seedsman for about 1s. a pound; it is very light, and 1 lb. will do many thousand grafts. It is strong, and at the same time soft and supple, and much better for the purpose than flax or string. It does not rot easily, but in wet localities or very moist soils it should be soaked in a very weak solution of bluestone before using. This prevents it rotting before the graft has united. Care, however, should be taken to rinse it in clean water after soaking in the bluestone solution, otherwise the copper might injure the cellular tissue of the callus. Wool is also suitable as a binding material, whilst fine rubber is the best ligature for use in green grafting.

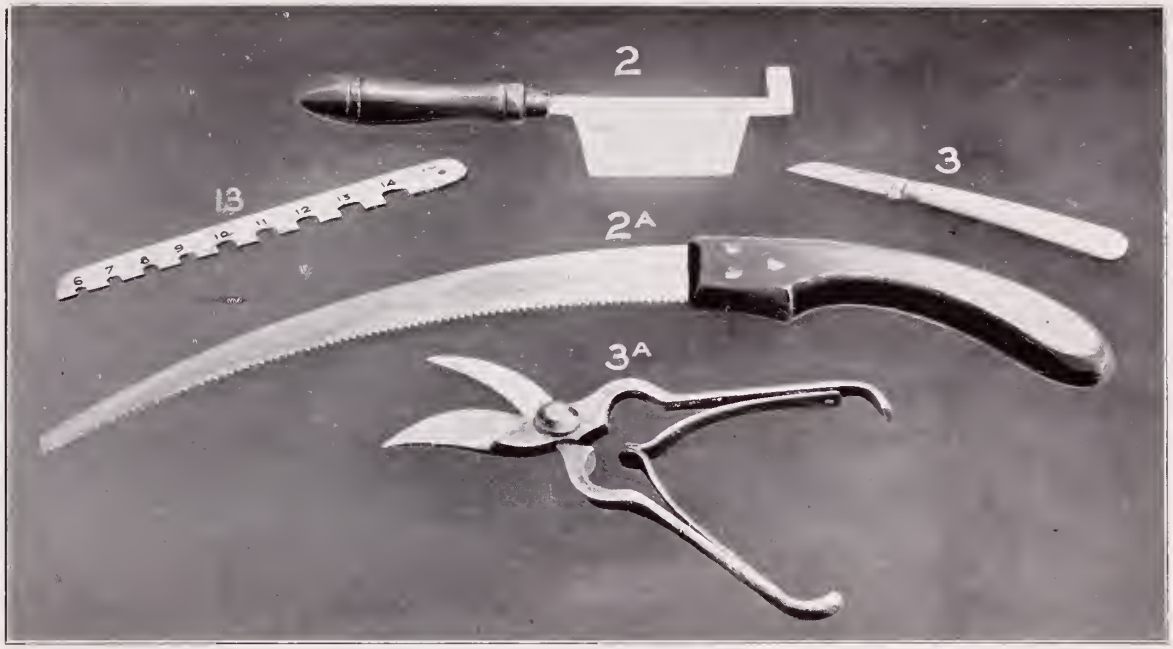
Methods of Grafting.

The chief consideration in the question of grafting is the choice of method to be adopted. There are numerous methods in existence, but for practical purposes we will limit ourselves to the seven principal ones, and select the best of these. Grafting may be performed upon either cuttings or upon rooted vines. The best known methods are the following:—

(1.) *Single or double cleft-grafting* .. For old vines.
(2.) *Side-grafting or Cadillac method* For old vines.
(3.) *English cleft-grafting* .. .. For cuttings or young rooted vines.
(4.) *English whip-tongue grafting* .. For cuttings or young rooted vines.
(5.) *Splice-grafting* .. .. For cuttings or young rooted vines.
(6.) *Coiffard method* .. .. For cuttings or young rooted vines.
(7.) *Green or herbaceous grafting* .. For old vines.

Single or Double Cleft-grafting. (On old rooted vines.)

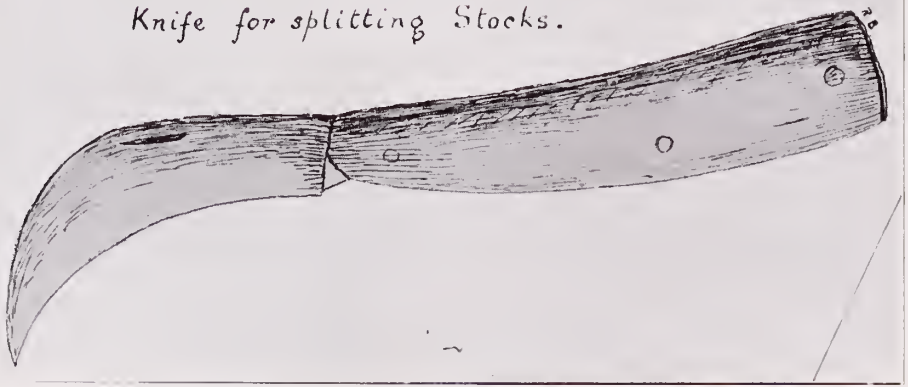
Before reading the following description of this method Figs. 5 and 5A should be carefully studied, so as to obtain a good idea of the nature of the operation.



Grafting-tools.—Fig. 2. Wedge-knife. Fig. 2a. Grafting-saw. Fig. 3. Grafting-knife. Fig. 3a. Secateurs. Fig. 13. Gauge for sorting Cuttings.

FIG. 4.

Knife for splitting Stocks.



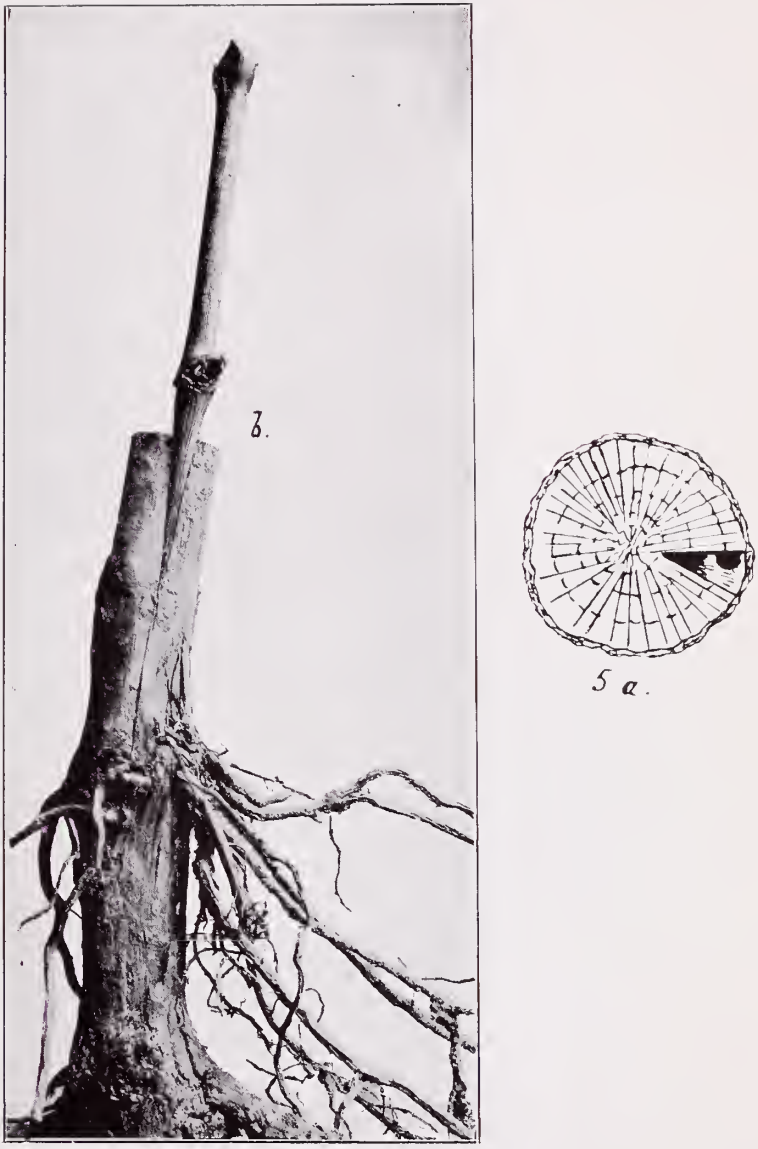


Fig. 5. Cleft-grafting on an Old Vine.

Fig. 6. Side-grafting, or Cadillac Method, on an Old Vine.— 6*a*. Scion ready for fixing. 6*b*. Scion inserted in Stock.

Fig. 7. English Cleft-grafting, Cuttings on Cuttings.

Fig. 8. English Cleft-grafting, on Young Rooted Stocks.

First of all, the soil should be cleared away from the trunk to a depth of 5 in. or 6 in. The trunk is then cut through horizontally with a saw about 2 in. or 3 in. below the level of the ground. Then, with the knife (Fig. 4) or wedge-knife (Fig. 2), cut down in one or two places (Fig. 5A), according to the number of scions the grower desires to work on to the stock. In making the cut, follow the direction of the grain of the wood, and keep the incisions open with wooden wedges or the steel one attached to the wedge-knife.

Scions must be cut in the winter or early spring before the sap begins to flow, and stored in dry sand until the time for grafting arrives. They should be taken from healthy fruit-bearing vines, and always from the lower part of the cane close to the trunk. Two buds should be left on the scion, and it is prepared by shaping the lower extremity with a clean, smooth cut in an oblique direction on both sides, leaving the wedge-shaped bottom thicker on the outer face than on the inside.

The scion is then inserted in the incision made in the stock, care being taken to bring the lower bud of the scion as close as possible to the surface of the trunk. In the operation the greatest care must be taken to make sure that the inner bark on the cut faces of the scion is brought in contact with, and exactly meets, the inner bark about the incision of the stock (see Fig. 5). The scion should only be prepared a few moments before it is inserted into the aperture in the stock.

The best time to carry out this method of grafting is in the late spring, when the sap of the stock is in free circulation and its leaves about 1 in. or 2 in. in diameter. By grafting at this time of the year the danger of bleeding is minimised. It is a good practice to prune the vines intended to be grafted, late in the spring, and thus permit them to bleed for a week or two before the grafting is effected.

It is also of the utmost importance that the buds of the scion should be dormant. If the scion is in leaf and the stock dormant when grafting the operation will result in failure, by reason of the shoots of the scion being unable to draw nourishment from the stock on which it is grafted.

After the scion has been inserted into the stock, the union is bound and covered with grafting-wax or clay. The soil is then replaced around the trunk and left slightly raised. When the buds of the scion have burst and the young shoots are about 5 in. or 6 in. long, the graft should be uncovered and the wax and binding removed. Any roots growing from the scion or at the graft must be cut away and all suckers suppressed. As the shoots from the scion increase in length they should be supported by tying to a stake.

Side-grafting or Cadillac Method.

This method is illustrated in Fig. 6, and differs in treatment from the ordinary cleft-grafting by being made at the side and above ground. It is generally adopted by growers who, while anxious to change the varieties of their vines, wish to obtain a crop or two from the original vines while the scion is developing, the old vine being removed at *a b*.

English Cleft-grafting.

This method is shown in Figs. 7 and 8, and to be successful it is necessary that stock and scion should be of the same thickness. Consequently it can only be applied to cuttings (Fig. 7) or young rooted vines (Fig. 8). The scion is prepared as shown in Fig. 7A, and when inserted in the cleft care must be taken to bring the inner bark at the sides of the wedge on the scion into contact with that of the cleft. The graft should afterwards be bound firmly with raffia.

Although easily performed, this method is not the most successful one. The reader will notice that the cut surfaces of both the stock and the scion are partly exposed, and this hinders the perfect knitting of the two. On account of these drawbacks I would not advocate its use by growers here.

English Whip-tongue Grafting.

The method I would strongly advise all growers to use for bench-grafting, in preference to any other, is the English whip-tongue grafting. This method may be described unhesitatingly as the standard method of grafting. It is illustrated in Fig. 9, and is equally adaptable for cuttings or young rooted vines.

Selection of Stocks and Scions.—It is essential, in order to obtain success in this method of grafting, that the scions and stocks should be of the same size in diameter, none less than $\frac{1}{4}$ in. through. An experienced operator has no difficulty in sorting them out in varying sizes to fit each other, but the gauge shown in Fig. 13 will assist the beginner in this matter. The reader will note that this gauge is fitted with nine gaps, numbered from 6 to 14. The size of a cutting is found by placing it in these gaps until the one it fits is ascertained. By this means they are sorted out on the bench in heaps, care of course being taken to keep the stocks and scions separate. Then No. 6 scions are worked on to No. 6 stocks, and No. 7 on No. 7, and so on. With practice the eye soon becomes trained, and the sorting-gauge may be dispensed with. Both scions and stocks should be selected from vigorous, full-bearing vines, free from disease. They should always be taken from the base of the canes, and never from the middle or end.

[Note.—The canes of the Riparia and other American vines are of almost the same thickness throughout the whole of their length, and it is difficult at first to distinguish between cuttings from the base of the cane and those from the middle or ends. This has given dishonest dealers an opening for foisting inferior cuttings upon growers. A simple test to determine which part of the cane the cuttings came from is to carefully examine the pith at the ends. If it is small and surrounded with a thick ring of wood it may be safely assumed that the cutting came from the base of the cane; if, on the other hand, the pith is thick and the wood only a thin ring, the cutting is from the middle or top of the cane, and should be rejected for grafting purposes. For, in addition to the difficulty of getting a smooth cut across the pith, there is always the risk of trying to mate cuttings from different parts of the canes. If in grafting the operator works a scion with a large thickness of pith on to a stock with only a small pith, there is an excess of sap from the stock and not sufficient wood on the scion to absorb it, the scion lacks vigour, and is drowned with the excess of sap. Worse still is the result following upon the attempt to graft a scion from the base of a cane and with a small pith, on to a stock from the tip of a cane with a large pith and small wood. It is obvious that in this case the stock will be unable to supply sufficient sap to nourish the scion, and through the wood of the stock, not being equal to that of the scion, the rising of the sap will be arrested at the graft, and, oozing out, will form a growth which in time may destroy the vine.

The operation of whip-tongue grafting is illustrated by Figs. 9A, 9B, 9C. A clean cut is made obliquely in a downward direction on the scion, and in an upward direction on the stock, at the angle shown in the illustration 9A. This cut should start nearly level with a bud on the opposite side, and its

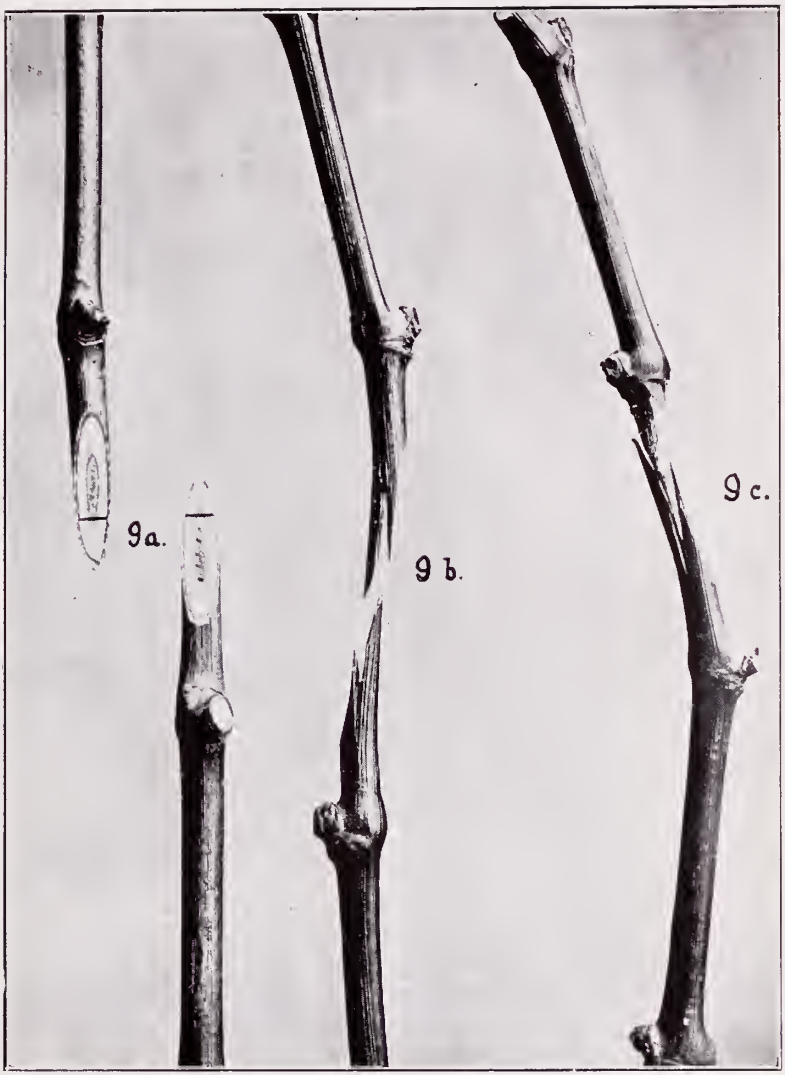


Fig. 9. English Whip-tongue Grafting.—*9a* Showing Position of Longitudinal Cuts. *9b*. Stock and Scion ready for Fixing, *9c*. Stock and Scion united.

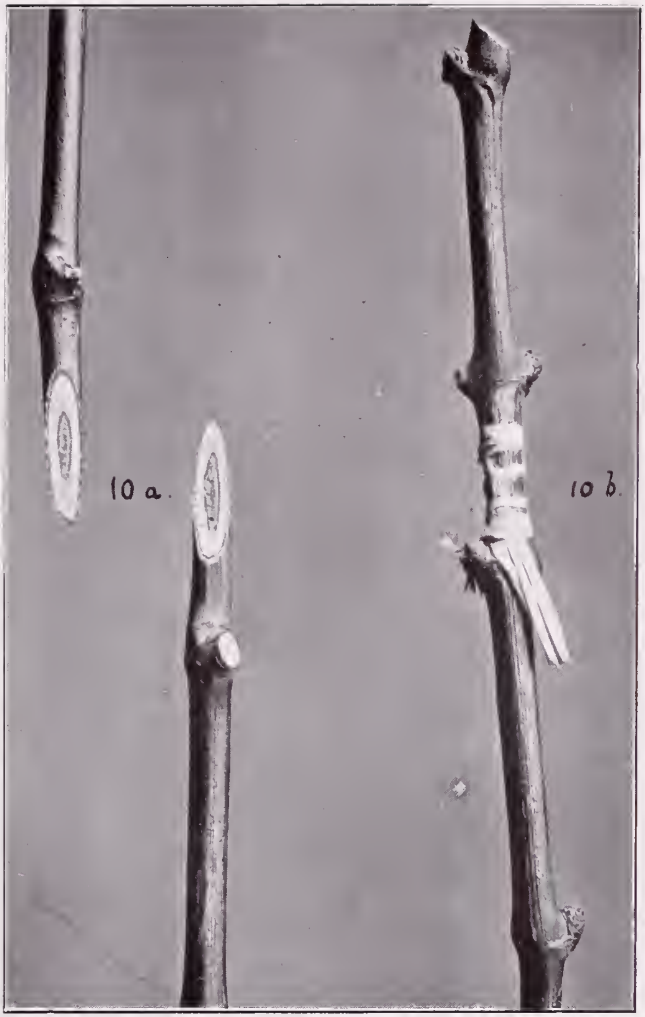


Fig. 10. Splice-grafting.—10*a*. Showing Preparation of Stock and Scion. 10*b*. Stock and Scion united.

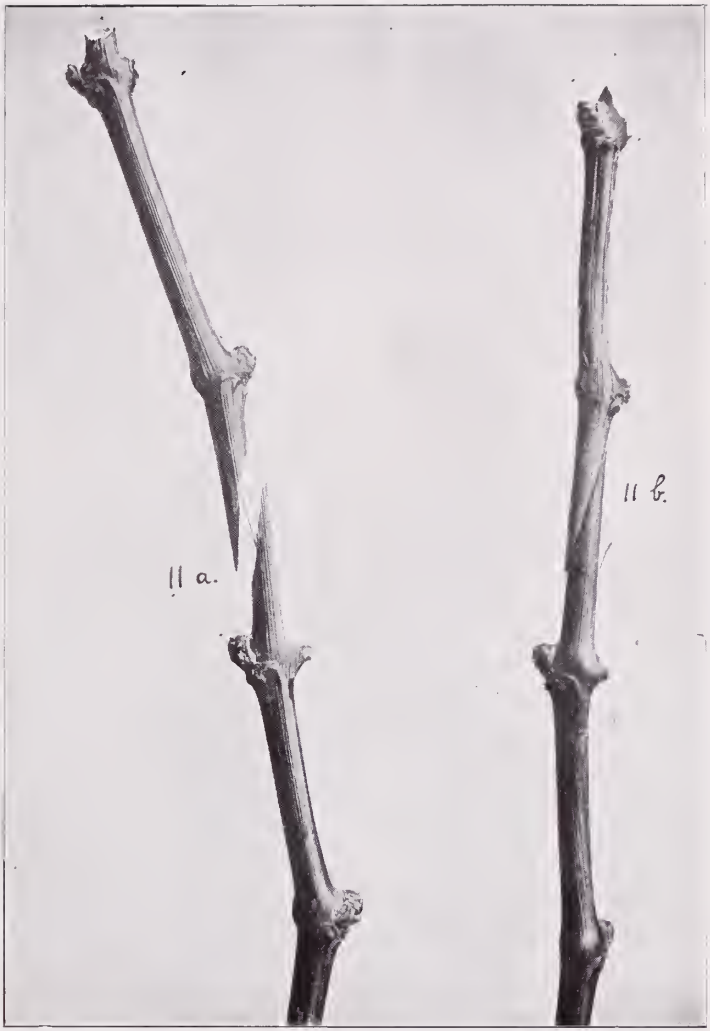


Fig. 11. Coiffard Method of Grafting.—11*a*. Showing Wire holding Stock and Scion. 11*b*. Stock and Scion united.

length should be about three times the thickness of the cutting. Then a longitudinal incision is made on both stock and scion about one-third of the way down from the point (Fig. 9A) and between the pith and the wood, following the grain of the wood to a depth of about $\frac{1}{2}$ in. As the knife is withdrawn a slight twist is given to open up the incisions (Fig. 9B). The tongues thus formed should then be fitted into the clefts firmly, so that the stock and scion meet and fit into each other perfectly (Fig. 9C.) The graft should now be bound up with raffia, care being taken to leave a space between the strands to allow of the free circulation of air around the newly made cuts. The binding may, however, be dispensed with where the grafted cuttings are to be calloused, as described below.

The advantages of this method of grafting are obvious. It may be done indoors at a bench or a table, on a rainy day or evening. It is pleasant work, and with a little practice is easily learnt; a skilful operator can get through from three to five hundred a day. Women and girls, having more dexterous fingers than men, are generally the best operators. This method is as easily applied to rooted vines as to cuttings, but in this case care must be taken to lift the vines carefully and gently shake the soil from the roots before bringing them to the grafting-bench.

Splice-grafting.

This method differs from the whip-tongue grafting, described above, in that the longitudinal cuts which form the tongues and clefts are dispensed with. The plain cut surfaces are brought together and bound (see Fig. 10). The precautions already mentioned under whip-tongue grafting with regard to the selection of stocks and scions must be carefully followed both in this and the Coiffard method, described below.

Coiffard Method.

This is a modification of the splice-graft, in which, instead of binding the stocks together, a piece of stiff wire about $2\frac{1}{2}$ in. long (Fig. 11A) is used to hold the grafted cuttings in position. The wire should be sharpened at both ends to avoid crushing the pith. The wire is inserted for half its length into the centre of the pith of the stock, and the remaining half is pressed through the centre of the pith of the scion (Fig. 11B.) The two are then pressed firmly together, and the cut surfaces, which have been prepared as shown for splice-grafting, are brought exactly in contact with each other (Fig. 11C.)

The great advantage of this method is that all necessity for binding is obviated, and a perfect graft is obtained equal to the English whip-tongue graft.

Callousing.

This is an important operation, by means of which the knitting tissue between the scion and the graft is started before planting out in the nursery. By this practice, now adopted in all wine-growing countries, a much higher percentage of successful strikings is secured to the grower. For the purposes of this operation it is necessary for the grower to be provided with a small forcing house or frame, where the grafted cuttings may be kept at an even temperature.

The grafted cuttings are placed in a box between layers of moist moss, and the forcing-house kept at a steady temperature of 60° for a month. Towards the end of this period it will be observed that a callus, or

growth of new uniting-tissue, is formed at the points of union between the scion and stock, and the buds burst, throwing delicate shoots. As soon as this callus is formed, the cuttings should be subjected to less heat and exposed to the full light. This will harden the callus and cause the leaves to turn green, thus preparing the cuttings for removal to the less equable temperature of the nursery. The operation is not a difficult one to carry out successfully, and the time and trouble expended on it is amply repaid by the increased number of successful grafts at the disposal af the grower.

A frequent cause of failure in callousing grafted cuttings is the presence of mould, which destroys the newly formed knitting-tissue and prevents a successful union. To avoid this the moss used should be thoroughly sterilised before being used by steaming it, or, failing this, by scalding it in boiling water. As a further safeguard against fungoid growths, pieces of wood charcoal should be placed throughout the layers of moistened moss.

Time of Callousing.

Another important factor in securing a high percentage of strikings is the time of performing the operation. It is essential that the soil should be in a warm state when the calloused cuttings are planted out, otherwise the sudden change of temperature from the warm atmosphere of the forcing-house to the cold soil of the nursery would destroy the knitting-tissue and cause many misses. The operation should therefore not be performed in winter, but deferred until the spring, about six or seven weeks before planting. Then it will be much easier to keep the forcing-house at an even temperature, and the soil outside will be sufficiently warm to plant out straightway in the nursery after callousing without any fear of a check.

After planting out, it is necessary to cover the ligature with a handful of sand or light soil. This prevents the callus being dried up and destroyed by the wind or sun. On the other hand, clayey or heavy soils should not be used for this purpose, as they prevent the free access of air, hampering the respiration of the new tissue, and, by keeping it wet, cause it to rot.

An Economical Method of Callousing.

Those growers who have no forcing-house or frames in which to carry out the callousing of the grafted cuttings can easily prepare a substitute in a spare room or barn, provided it is weather-tight and well lighted. All that is necessary is a load or two of hot fermenting stable-manure and some sand. The manure is spread out on the floor of the room to a depth of about 18 in., and is trodden down firmly all over. It is then covered with clean sand to a depth of about 4 in. The grafted cuttings are stuck upright in the sand, care being taken that they do not penetrate into the stable-manure. They are then covered in with sand so as to fill in all the spaces between the cuttings, and at the same time completely cover them.

After forty days it will be found that the callus has formed and the grafts have knitted, the stock will have begun to send out roots, and the buds of the scions burst, emitting young shoots.

As soon as the temperature outside is warm enough to allow of the cuttings being planted out, the sand should be carefully removed and the cuttings lifted for planting in the nursery.

Planting the Grafted Cuttings.

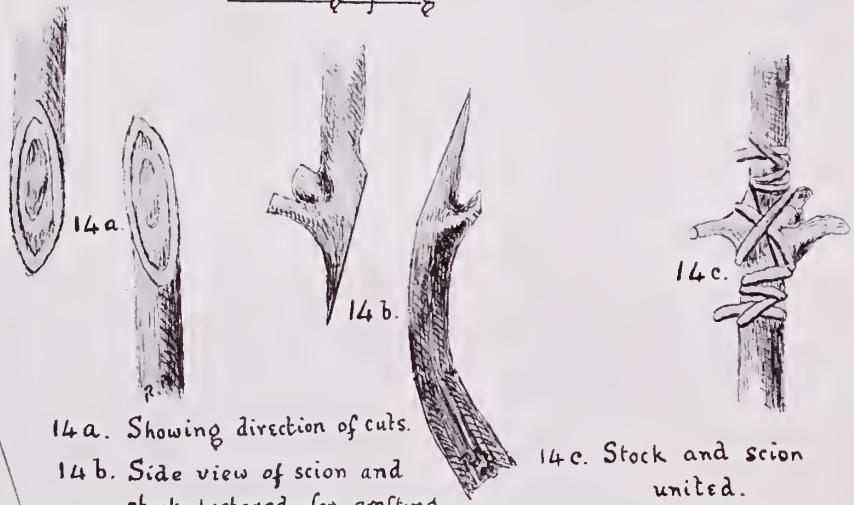
The nursery having been well prepared, a trench is opened up in the same way as described for cuttings. A few tin cylinders should be procured,

FIG. 12.

Method of planting grafted cuttings

FIG. 14.

Green grafting.



14a. Showing direction of cuts.

14b. Side view of scion and stock prepared for grafting.

14c. Stock and scion united.

about 9 in. long and 3 in. in diameter. Stand them upright in the trench about 6 in. apart, and place the grafts upright in the cylinder. Care must be taken to make sure that the union of the grafts is level with the surface of the land (Fig. 12). The cylinder is then filled up with sand to the top, and the space around the cylinder with loose soil. The cylinder is then withdrawn and the earth pressed gently around the sand with the foot. By this means the grafted cutting is left surrounded with sand, and in this it roots easily.

Green Grafting.

In addition to the foregoing methods of grafting, an important one is that largely practised in Hungary, and which is destined to play an important part in the reconstitution of vineyards with American stocks. It is known as herbaceous or green grafting, and is performed by the juxtaposition of the two nodes or bud portions of the green wood. The best method of performing it is the one shown in Fig. 14.

The best time for this operation is in the early summer, and on a calm sunny day when the air is not too humid. To be successful it is necessary that the shoots of both stock and scion are well developed, and at least $\frac{1}{4}$ in. thick.

The vines which are to be used as scions and stocks should be prepared at least a fortnight beforehand by suppressing all suckers, and, in the case of the American stocks, as many shoots should be left as the vine is years old; care, of course, being taken to leave the strongest and best ones. All others should be removed, and by this means the flow of sap is concentrated into the shoots selected.

The most difficult part of the operation is the selection of the nodes where the cuts are to be made. The first consideration is that the shoot must be fully developed and at least $\frac{1}{4}$ in. thick. The shoot must be not too woody nor at the same time too green. If they are too woody and the pith has begun to form, the grafting will not take; whilst if too green, the shoots will be too soft and brittle, and will in consequence be bruised and crushed in the binding. The shoot should be supple enough to stand a certain amount of bending, and at the same time sufficiently young to snap clean when broken. The best way to determine this is to pass the hand down the shoot and gently squeeze the nodes until the one is found where the shoot ceases to be green, but has not yet begun to be woody or develop pith. With a few trials and experiments the grower will soon be able to determine the right nodes.

Preparation of the Stock and Scion.

The scions are separated from the European vine immediately before use, and should be taken about three or four leaves beyond the last bunch; the top part is pinched off, leaving two buds on the portion to be used. The leaves are removed, leaving about $\frac{1}{4}$ in. of petiole adjoining the lower bud. The scions should at once be wrapped in a moist cloth and kept wrapped up until required for use.

The nodes having been chosen, the stock is prepared by cutting through the node in an oblique direction upwards, the incision beginning just below the bud, thus removing it and leaving the stump of the tendril on the opposite side. The scion is cut downwards at the same angle through the node, the cut in this case beginning behind the bud and allowing it to remain with the petiole (Fig. 14B). It is essential that the stock and scion should be of the same thickness, not less than $\frac{1}{4}$ in., and not more than $\frac{3}{8}$ in. diameter.

The cut surfaces of each should fit perfectly and cover each other completely (Fig. 14c). These cuts should be made with a sharp knife having a wide plain blade of very thin steel. It should be kept scrupulously clean, and should have a thick handle, which allows of a firm, steady grip.

Ligaturing.

The cut surfaces are held in position and bound firmly with thin india-rubber ribbon, about 6 in. long. This is much better for the purpose than raffia, wool, or string, as it holds the joint firmly, and, being elastic, does not crush or bruise the tender tissue. The union is complete in fifteen or twenty days, and the following winter the graft is cut away from the parent stock and planted out in the nursery to root.

LAYERING.

A simple and quick system of propagating those American vines difficult to strike from cuttings is the layering method advocated by Cavazza (Fig. 16). Early in the spring trenches are opened up 10 in. or 12 in. deep; the trenches should run from the trunk outwards in the direction the canes would lie, and of the same length as the canes: as many trenches being opened up as there are canes to be layered. The canes should be of one-year-old wood, and prepared by twisting a strand of wire around the middle of the internodes to assist them in rooting. The cane is pegged down along the bottom of the trench, and in the summer, when the shoots are a foot or so high, the soil is filled in around them, leaving the tip exposed above the level of the ground.

From the buds on the portion of the shoots below the ground are sent out roots, and the shoots develop vigorously. These may be grafted by green grafting, *b*, *b*, *b*, or, when the wood has ripened, by ordinary methods; and the following spring the earth is taken out again and the rooted plants cut away at *a*, *a*, *a*, *a*. By this means as many grafted rooted vines are obtained as there were buds on the cane which was layered. If the green grafts fail to take, there are still the rooted American stocks at the disposal of the grower, which may be grafted the following season.

CHAPTER IX.

EUROPEAN VINES FOR SCIONS.

APPENDED for the guidance of growers is a brief description of those varieties of European grapes for grafting on American stocks which have been studied and tested in this country, and which have proved their suitability.

Red-wine Grapes. — CABERNET SAUVIGNON, CABERNET FRANC, MALBEC, HERMITAGE (or SHIRAZ), PINEAU MEUNIER, and PINEAU NOIR.

White-wine Grapes.—PINEAU GRIS, PINEAU BLANC, LA FOLLE, CLAIRETTE BLANCHE, MARSANNE, RIESLING, and VERDEILHO.

Other varieties are being experimented with, and I am importing new varieties of wine-grapes from France, Northern Italy, and Austria, where the climate much resembles that of the wine-growing districts of New Zealand: and those vines which flourish in the countries named should do well here.

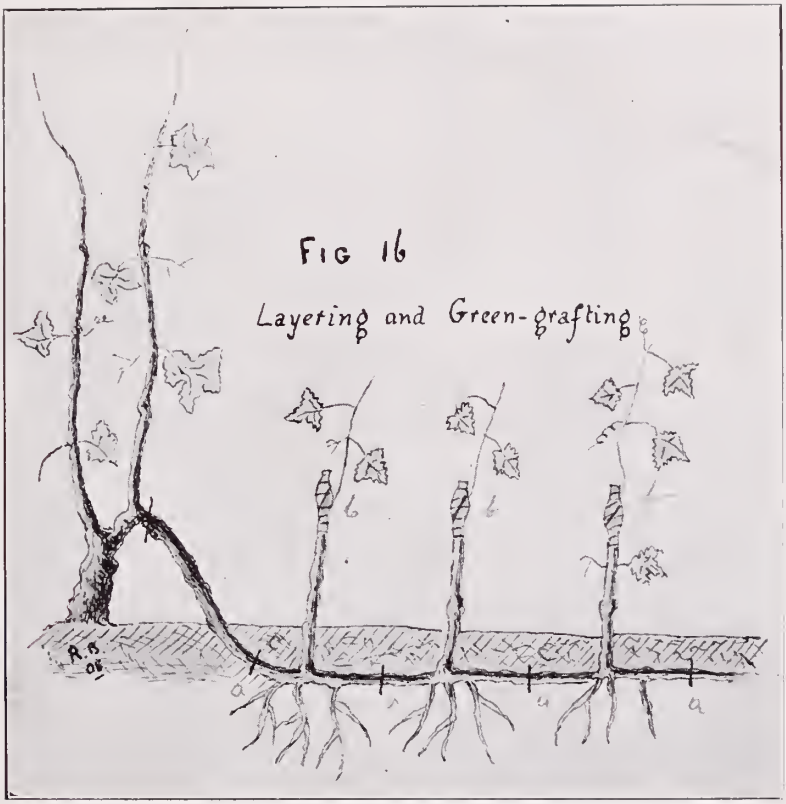


FIG 16

Layering and Green-grafting

For outdoor table-grapes the best varieties for grafting on American stocks are *Black Hamburgh*, *Royal Madeline*, *Early White Malvasia*, and *Sweetwater*. These are all well suited for outdoor culture in the North Island. The *Albany Surprise*, a local grape of American parentage, has been extensively cultivated here as an outdoor table-grape, and has yielded good results. It must be grafted on to a resistant stock, as, although an American vine, its resistance to phylloxera is very weak.

Other varieties of European and American table-grapes have been procured and are being experimented with, the results of which will be communicated to growers at a later date.

Wine-grapes best suited to different Localities.

Northernmost New Zealand (Hokianga, Bay of Islands, &c.).—Cabernet Sauvignon, Cabernet Franc, Hermitage, Pineau Meunier, Pineau Gris, Pineau Blanc, La Folle, and Clairette Blanche.

Kaipara, &c.—Cabernet Sauvignon, Hermitage, Pineau Meunier, Pineau Blanc, La Folle, Clairette Blanche, Marsanne, Riesling, and Verdeilho.

Auckland District and Waikato.—Cabernet Sauvignon, Hermitage, Pineau Meunier, Pineau Noir, La Folle, Clairette Blanche, and Marsanne.

Hawke's Bay.—Cabernet Sauvignon, Hermitage, Pineau Meunier, Pineau Blanc, La Folle, and Clairette Blanche. The Malbec, which does not do well farther north, yields good crops here.

Wine-grapes.

Cabernet Sauvignon.

One of the best varieties grown here, and equally well suited to all the wine-growing districts of the colony. It stands extremes of climate well: in fact, the bunches may be allowed to remain on the vines till late in May. It yields a heavy crop of fruit, the bunches being loose, and free from the attacks of mould during ripening, the berries having a thick skin heavily coated with bloom.

The must obtained from this grape is rich in saccharine matter and colour, and the wine produced is of an excellent quality.

Hermitage (Shiraz).

The well-known variety of the celebrated Hermitage vineyards in France. It bears well here, is free from mould, and gives a good wine.

Pineau Meunier and Pineau Noir.

The first is somewhat subject to attacks of mould in late wet seasons, but generally speaking bears heavily here, and in normal seasons produces a good crop of high-class wine. The Pineau Noir is liable to be affected by *couler* or non-setting when the spring is wet, but ordinarily it bears well and yields a nice wine.

Cabernet Franc.

This is a very valuable variety, and has succeeded well in the northernmost parts of the colony. Unfortunately, it seems to be subject to *couler* south of these districts.

Pineau Gris.

Like the Cabernet Franc this variety does well in the far north. It is an early grape, bears heavily, and produces an excellent white wine.

Pineau Blanc.

This variety does well in all districts, and makes good wine.

La Folle, Marsanne, and Clairette Blanche.

These three varieties of white grapes are well adapted to all districts. So far, however, the cultivation of the La Folle and the Marsanne has been limited to Waerenga, and the Clairette Blanche to the Kaipara. In these instances they have succeeded well.

Malbec.

The Malbec is a very fine grape, which grows well in the Hawke's Bay district. Unfortunately, it is less productive in the northern districts, where, owing to the cold winds and rains which often prevail at the time it blossoms, it does not set so freely.

Verdelho and Riesling.

These varieties have done satisfactorily so far in the Kaipara and Waikato, but being only fair bearers I would not strongly advise their use. At the same time, these two varieties produce a very superior wine.

CHAPTER X.

THE VINEYARD.

Aspect.

We have already discussed the soils best suited to a vineyard. A matter for more serious consideration is the aspect. The more sun it receives and the more it is protected from the cold winds, the better the vines flourish, and the better the wine produced

The ideal aspect is one where the sun shines from rising in the morning to setting at night. The early sun in the morning is of more value than the setting sun at night, as it warms up the soil sooner. Consequently a gentle north-easterly slope or rising ground is to be preferred to level land, as by this means the vines are protected from the cold southerly and south-westerly winds which prevail in this country, especially along the west coast.

In addition to this, land sloping to the sun is always warmer than level ground, the rays of the sun falling in a more direct line.

Another necessary factor to the success of the vineyard is shelter. The high south and south-westerly winds usually prevail during the period of blossoming, and, to secure the free setting of the fruit, shelter-belts of a quick-growing nature should be planted.

Having, then, selected a spot with a north-east aspect and well sheltered from the cold winds, the next question is the preparation of the soil.

Preparation of the Land.

If the soil is virgin land it must be cleared of all stumps and roots, and drained by means of open drains before trenching. In light, sandy soils, with sandy or gravelly subsoils, deep trenching is unnecessary, and it is sufficient to work the full depth of the cultivable soil, and care should be taken not to bring the subsoil to the surface. In all other kinds of soil deep trenching must be done, as it is absolutely necessary for the establishment of a successful vineyard, and the deeper the land is trenched the better will be the result.

This method of preparation is always adopted in the wine-growing countries of Europe, as will be seen from the following list :—

		Depth of Trenching. Inches.
Provence,	*S. France*	30–39
Hermitage,	*S. France*	50
Douro,	*Portugal*	30–59
Bordeaux,	*W. France*	24
Beaujolais,	*Middle France*	24
Burgundy,	*N. France*	14
Champagne,	*N. France*	12–24
Italy	.. ..	18–36

The American stock requires a deeply worked soil to allow of it rooting freely and deeply; and while deep trenching is an expensive item, the result will always repay the vigneron for the labour and money expended, and in the long-run it will be found more economical and useful than 8 in. or 10 in. working of the soil.

By deep trenching the vine is given a larger field of nutriment. It induces the roots to go down which would otherwise remain on the surface, it drains the soil to a great depth, keeps it sweet, open, and warm, and thus minimises the effect both of excessive moisture and dryness.

As the result of these advantages, the life of the vine is lengthened, it is healthier and less subject to disease, it is more vigorous, and naturally yields a heavier crop of better fruit than those planted in shallow-worked soils. It is folly for the would-be vigneron to imagine that he can establish a successful vineyard in soil that has only been scratched to a depth of 6 in.

In trenching, the subsoil should be brought to the surface, except in those cases where it is stony, gravelly, or calcareous, and in those instances where it is of such a nature that it does not break down well when exposed to the weather, such as stiff pipeclays.

The most economical method of trenching is done with two ploughs—the first an ordinary plough, which goes to a depth of from 8 in. to 10 in., and the second a trenching-plough, which goes down another 10 in. or 12 in. The depth is, of course, dependent on the amount of haulage-power available. The second, or trenching-plough, brings the subsoil to the surface, and where this is not wanted a subsoil-plough is used. This has no mould-boards, and breaks the subsoil without bringing it to the surface.

After deep trenching, the question of draining must be decided (see Chapter XIII.), and the land should be left rough for a year to allow it to become mellowed by the weather.

Before planting, it should be levelled with a smoothing board or roller, harrowed, ploughed shallow, and again scarified to bring it into a condition fit for planting.

The ground being thus prepared, the direction of the rows should be marked out. The rows should be run from north to south, as by this means both the sides of the vines and the ground between the rows receive the sun's rays more equally, and the effect of the shade cast by the vines is lessened.

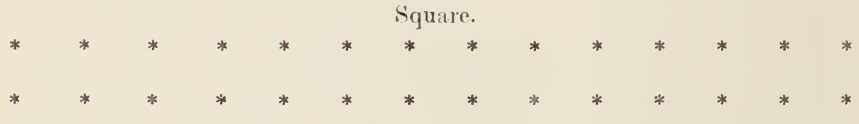
The direction of the rows having been decided, pegs are driven in to mark the spots for planting the vines. The distance between the plants and the rows varies with the climate, soil, cultivation, method of pruning, and variety of grape cultivated. The vineyard may be planted either in the oblong, diamond, or square pattern.

The following shows the different methods of planting :—

Oblong.

Diamond.

Square.



The first is the method commonly adopted, and the distance between the plants should, as a general rule here, be 6 ft., with 8 ft. between the rows to permit of a horse-hoe or dray being used between the rows without injuring the vines. Growers here who are accustomed to closer planting must remember that the American resistant stock is usually a very free rooter, and this habit should be encouraged by placing a large area of ground at its disposal. This induces a stronger resistance to phylloxera, and assists it to withstand any unfavourable condition of the soil.

Planting the Vineyard.

After the land has been marked out ready for planting, the grafted stocks may be removed from the nursery. They should be lifted with great care with a fork, every precaution being taken to avoid injuring the roots. Only a few should be lifted at a time, and they should be carefully wrapped in a wet cloth, to preserve them in good condition until the hole in the vineyard is ready to receive them.

The holes should be from 9 in. to 1 ft. deep, and large enough to permit of the roots being spread out equally in all directions. A small quantity of well-rotted stable-manure should be placed in the bottom of the hole,

Fig. 17. First Year's Pruning.

Fig. 18. Second Year's Pruning.

and lightly covered with a layer of good loose soil. When the vine has been placed in position it should be covered in with fine soil mixed with decomposed stable-manure. The soil around the plant should then be firmed gently with the foot.

Time of Planting.

The best time for planting rooted vines in this country is in August The after-cultivation consists principally of frequently stirring the soil between the rows and between the plants, to eradicate any weeds which may appear and rob the vine of its nutriment.

During the summer the soil should be removed from around the plants, and any roots appearing above the graft should be cut away with a sharp knife, as they come from the non-resistant scion and flourish at the expense of the stock. All suckers growing from the stock must be suppressed. In addition to this the shoots on the scion should be supported by tying them to a stake. The vines should be sprayed once or twice with Bordeaux mixture, and dusted with sulphur to prevent the appearance of oidium and other fungoid diseases. For particulars of these operations the reader is referred to my forthcoming book on " Diseases and Pests of Grape-vines."

CHAPTER XI.

PRUNING AND TRAINING.

First Year's Pruning.

About August all the shoots except one should be cut away with a clean cut, close up to the trunk, with a secateur or a sharp knife. The shoot left should, of course, be the strongest one, and this should be cut back to one bud (see Fig. 17). This concentrates all the energy of the vine upon one bud, thus enabling it to grow vigorously the following season and provide a strong trunk for the future. The shoot growing from this bud must be tied to a stake for support, and should be sprayed and sulphured during the summer. The ground should be ploughed shallow between the rows, and scarified two or three times as rendered necessary by the growth of the weeds. Frequent stirring of the soil is always advisable, as it keeps the land fresh and friable. In this condition it absorbs the dew and allows the rain to penetrate deeply, whilst in dry weather it induces the moisture below to come to the surface by the capillary action of the loose soil.

any of the vines have failed they should be replaced this year.

Second Year's Pruning

If the vine has been treated as described above during the second year it should now show a strong, healthy, and well-formed shoot. In August or September this is pruned back, *a*, *b*, to leave a spur with two buds (see Fig. 18), and these buds produce two shoots which form the crown of the vine. The same process of cultivation, spraying, and tying should be carried out as advised for the previous year.

In the following winter the system of pruning to be adopted must be decided, and I would here like to seriously warn the grower against pruning

all vines alike. The method of pruning must vary with the different grapes, the nature of the soil, and the conditions of climate.

Systems of Pruning.

There are two systems of pruning, *short* and *long*, and all the different methods are modifications or combinations of these two systems.

In pruning the vine, the aim of the grower must be to bring the vine into such a condition as will enable it to supply an abundance of fruit in the ensuing season, and at the same time make provision for strong and healthy wood for the future.

Short Pruning.

Third Year's Pruning.

This system is very easily carried out, provided the vine has been pruned as directed during the first two years. It consists in cutting back the shoots on the two-year-old wood to two buds, regulating the number of spurs left by the strength of the vine, the variety of grape, the richness of the soil, and the nature of the climate.

If an examination is made of a three-year-old vine, as shown in Fig. 19, it will be seen that to prune it properly in the third year it should be cut as shown in Fig. 19, *ab*, *ab*. When the vine has been so pruned there will be left a trunk with two spurs, each bearing two buds, as shown in Fig. 19A.

Fourth Year's Pruning:

Before pruning this year the vine will present the appearance shown in Fig. 20, and if the vine is strong the four shoots growing from the buds left in last year's pruning should be cut back to two buds each, as shown at *a*, *a*, *a*, *a*, in Fig. 20.

The same course should be adopted in the years following, care being taken that the vines are not carried too high from the ground, as this would interfere with the ripening of the fruit. The spurs chosen should always be the lower ones, and on two-year-old wood. They should not be allowed to cross or become entangled with each other, and sufficient space should be left in the centre of the vine to secure good ventilation and allow the free access of heat and light to the vine.

The above is a brief description of the spur system of short pruning, which, I hope, will be sufficiently clear for the grower to comprehend and put in practice when suited to his requirements.

Long Pruning.

As most of the varieties I have recommended for the use of wine-growers in this country are best suited by the long-pruning system, I append a description of this method.

I have already stated that pruning is performed with two objects in view—(1) The production of fruit in the ensuing season; (2) the securing of good wood for future bearing. These two aims are necessarily connected, and by careful application of the methods here described the grower should be able to attain both, and so lay the foundations of a sturdy vineyard.

To induce the vine to bear fruit it is necessary to have the bearers or spurs growing on two-year-old wood. In the case of long pruning it is necessary to prepare new wood each year, which will replace the bearing

Fig. 19. Third Year's Pruning.

FIG. 19A. CROWN OF VINE AFTER THIRD YEAR'S PRUNING.

Fig. 20. Short Pruning.—Appearance of Vine before Fourth Year's Pruning.

Viticulture.

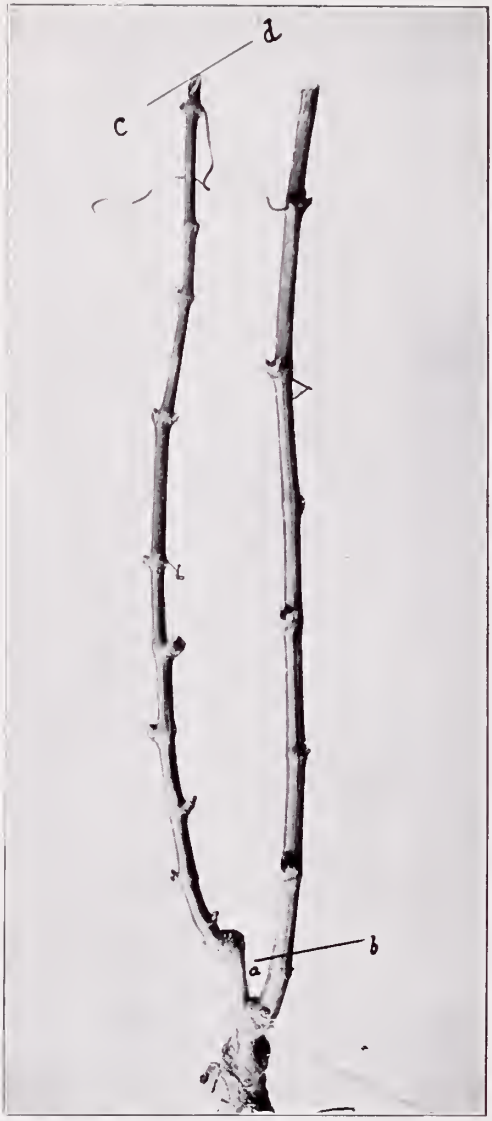


Fig. 21. Combined System of Pruning.—Appearance of Vine before the Fourth Year's Pruning.

Viticulture.

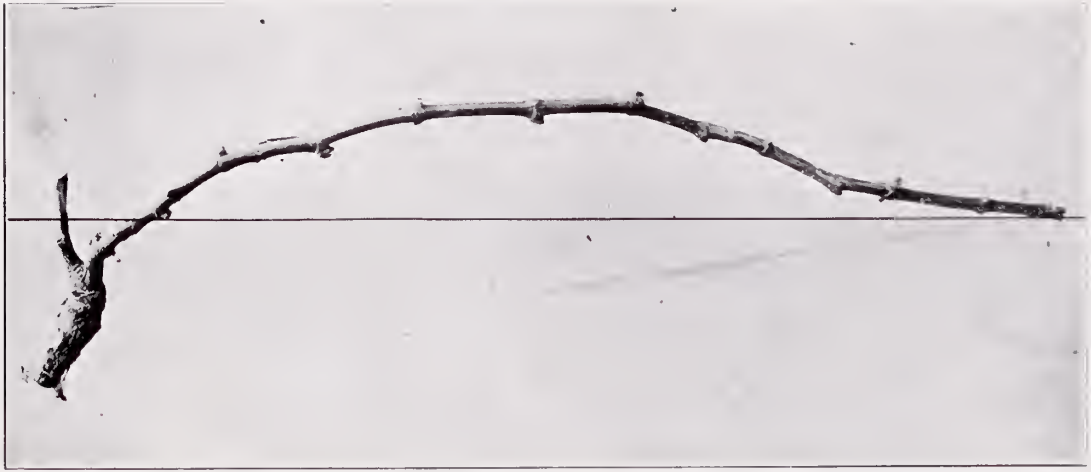


Fig. 21a. Combined System of Pruning.—Bearing-rod tied in Position after Fourth Year's Pruning.

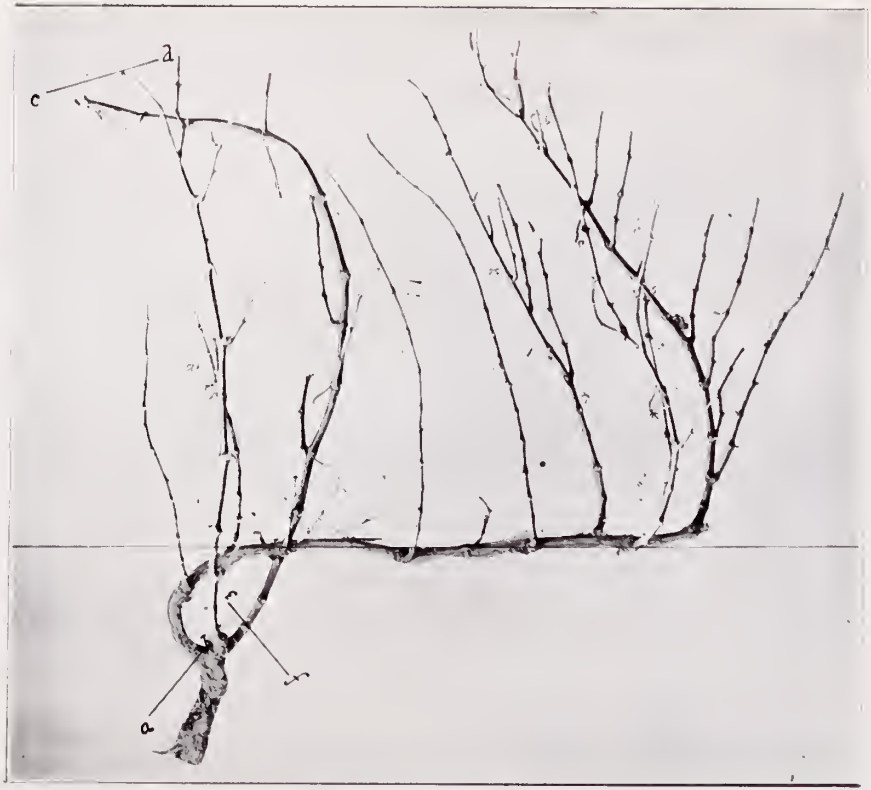


FIG. 22. COMBINED SYSTEM OF PRUNING.—APPEARANCE OF VINE BEFORE THE FIFTH YEAR'S PRUNING.

wood of the year previous, as otherwise the vine will yield but little fruit. We see from this that the principal object of pruning must always be to prepare one year for the next year's bearing wood, and in order to obtain new and well-nourished wood the vine must be pruned short. With short pruning, however, much fruit is lost, but the shoots are stronger and the fruit produced is larger than in the case of long pruning, where the shoots are weak but much more heavily laden with fruit.

The reader will thus observe that each system has its advantages and its drawbacks. The question which naturally arises is, can we obtain the advantages which pertain to each system, and at the same time avoid the disadvantages? If so, how may we combine the two systems so as to obtain the strong shoots resulting from the short pruning, and at the same time secure the more abundant crop yielded by the long system? The answer is very simple. Instead of leaving eight, twelve, sixteen, or more buds divided between four, six, or eight spurs, as we do in short pruning, we may leave only two shoots on the vine. The lower one is pruned *short*, leaving two buds, and the upper one is pruned *long*, leaving six, eight, twelve, or more buds, being guided by the strength of the vine, the soil, and climate.

Combined System of Pruning.

At the end of the third year the crown of the vine will have been formed, and will appear as in Fig. 19A. In the fourth year's pruning the lower shoot is pruned *short* at *ab*, leaving two buds, whilst the other shoot is pruned *long* at *cd* (Fig. 21), leaving eight, ten, or twelve buds, according to the varying conditions mentioned.

The long or fruit-bearing shoot is then tied in a horizontal position to the bottom wire of the trellis (Fig. 21A). This shoot will bear fruit the following summer, after which it is cut away close up to the trunk. The buds on the short spur will, of course, be dealt with in the same manner as described above for pruning in the fourth year. By this means we combine the advantages of the two systems of pruning, and with the two cuts described cause the vine to produce the abundant crop of the long-pruning system, and at the same time provide strong canes for future bearing.

In further illustration of this combined method, take the case of the vine at the beginning of the following or fifth year (Fig. 22). This differs from the fourth year in that it has two upright shoots produced from the two buds left by the short cut, and one two-year-old cane, trained to the trellis, which has borne fruit in the past season. Last year we only needed two cuts, but in this and all the years following, three cuts will be necessary. The first, to cut away altogether the wood which has borne fruit, *ab* (Fig. 22). The second cut is on the highest situated vertical, or one-year-old shoot, *cd*, and the number of buds the vine will stand are allowed to remain, to replace the bearing wood which has been cut away. Thus this shoot is cut back to eight, ten, twelve, or more buds as required, and will come down to the bottom wire to bear fruit the next season. The lower upright shoot is cut short, *ef*, leaving two buds to provide two shoots for pruning next year.

After the three cuts have been made, the vine will present the appearance of Fig. 21A, and every subsequent year the pruning is merely a repetition of this method.

Where, however, the soil is rich and deep, and the vine strong and robust, more expansion may be allowed, and two bearers and two spurs may be left instead of one of each. In this case the same system is adopted as above

mentioned, the only difference being that the wood left is just doubled. This system of pruning, when the principle has been mastered properly, is as simple as the single one.

Cazenave-Marcon System.

Where the soil is rich and fertile and the vines vigorous and robust, this is a valuable method and one well suited for use in this country. The method is a variation of the combined system of long and short pruning just described. The difference consists of laying down to the bottom wire a permanent rod, which is allowed to remain for several years.

The method is illustrated by Figs. 23, 24, 24A, 25, 26, and 27, and is performed as follows :—

When the vine has reached its fourth year, and the crown has been formed as shown in Fig. 23, the stronger of the two shoots is selected as a permanent rod, and is tied down to the bottom wire of the trellis (Fig. 23). The other shoot is pruned to one bud this and each subsequent year, so as to be available for replacing the permanent rod in the future if required. When the permanent rod has been tied to the wire, all the buds on the under-surface must be suppressed close to the rod, and the buds on the upper surface must be thinned out in such a manner as to leave a space of about 12 in. between each bud ; those buds not required must be removed close up to the wood.

The following summer the shoots growing from the remaining buds should be supported by tying to the second wire, and stopped when about 18 in. long. In the following winter the vine will present the appearance shown in Fig. 24. When the pruning period arrives these shoots are pruned short to two buds (see Fig. 24, *ab*, *ab*, *ab*), and after pruning will present the appearance shown in Fig. 24A. These two buds on each spur produce two shoots the following summer (Fig. 25), the upper of which become the fruit-bearing shoots for the next year, while the lower provide the shoots for the future supply of wood. Each then of these pairs of shoots may be taken as representing a miniature vine in bearing, and is treated as such by being pruned by the combined system of long and short pruning described on page 37. The upper shoots are pruned long at *b*, *b*, *b*, *b*, leaving from eight to twelve buds, the number being regulated by the richness of the soil and the strength of the vine. The lower shoots are pruned short to two buds at *a*, *a*, *a*, *a*, thus providing from these two buds two shoots for pruning the following season. The long bearing-shoot is trained to the wire above the permanent rod in an angular direction as shown in Fig. 26, or, if its length permits, is looped around as shown in Fig. 27, and tied to the rod.

The pruning in the subsequent seasons is merely a repetition of the combined system : each year the bearing-canes are cut away close up to the permanent rod ; the upper of the two shoots from the spur left last year is pruned long, and trained to replace the bearing-cane cut away, whilst the lower is pruned short to two buds which provide two shoots for pruning next year.

When, after many years of bearing, the spurs on the permanent rod become barren or sightless, the permanent rod may be cut away close up to the trunk, and the shoot which has been grown each year from the crown of the four-year-old vine may be tied down in its place, and proceed as before.

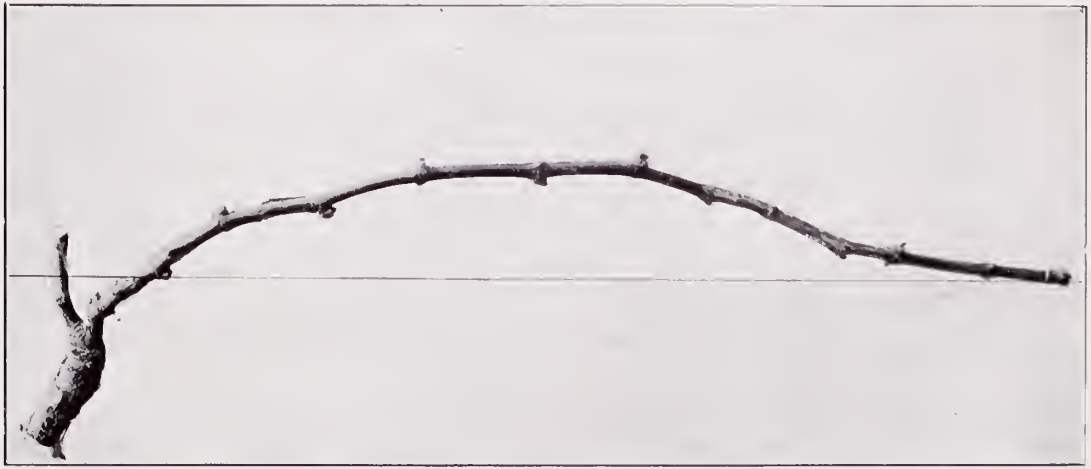
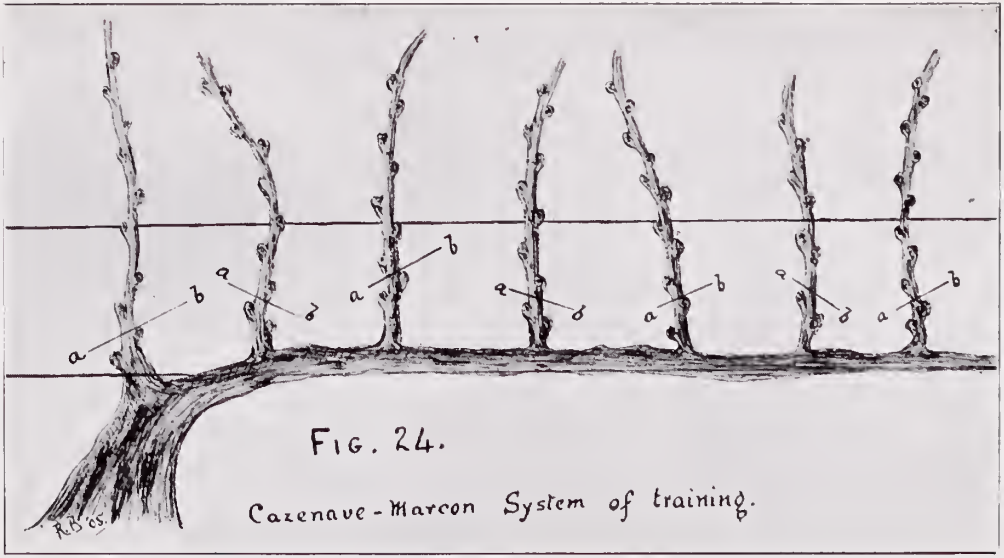


Fig. 23. Cazenave-Marcon System.—Permanent Rod tied to Trellis after Fourth Year's Pruning.

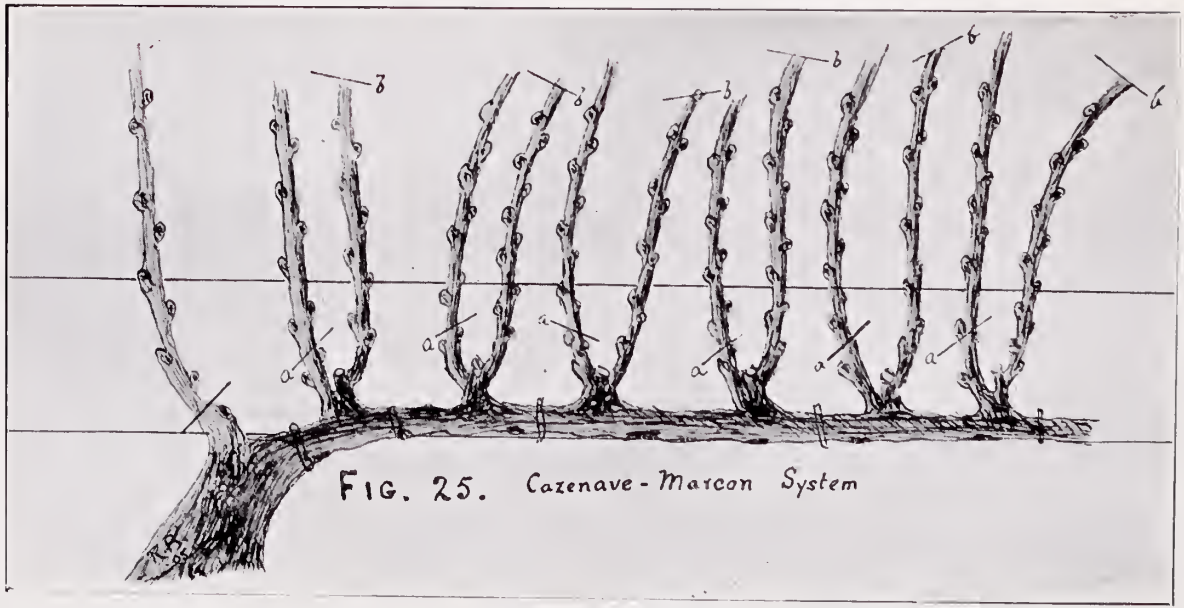
Viticulture.



APPEARANCE OF VINE BEFORE FIFTH YEAR'S PRUNING.

Fig. 24a. Cazenave-Marcon System.—Permanent Rod after Fifth Year's Pruning.

Viticulture.



APPEARANCE OF VINE BEFORE SIXTH YEAR'S PRUNING.

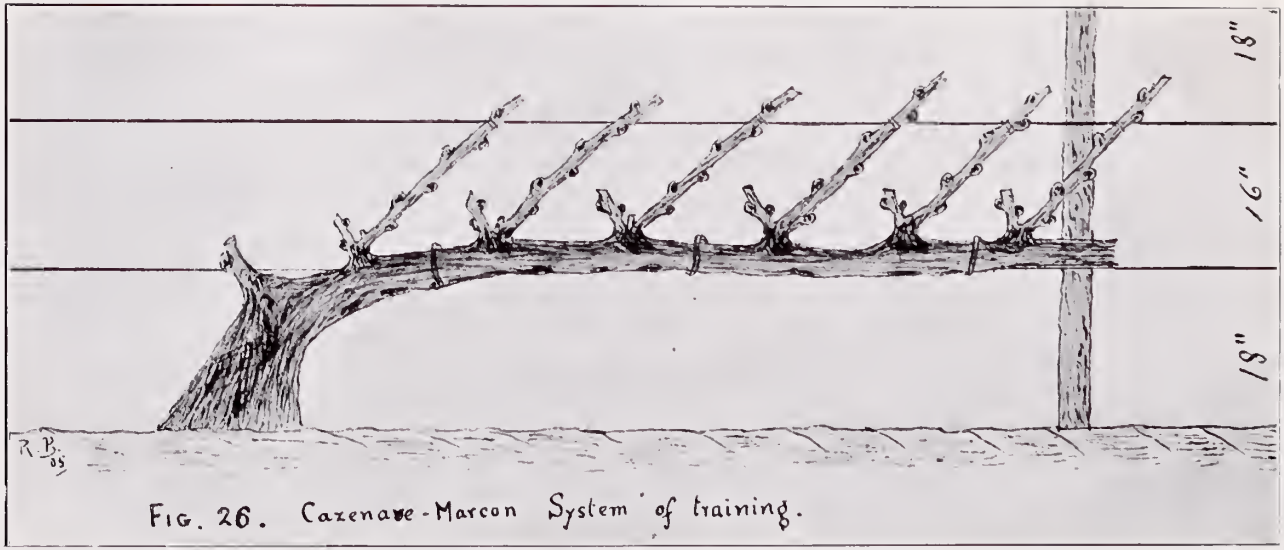
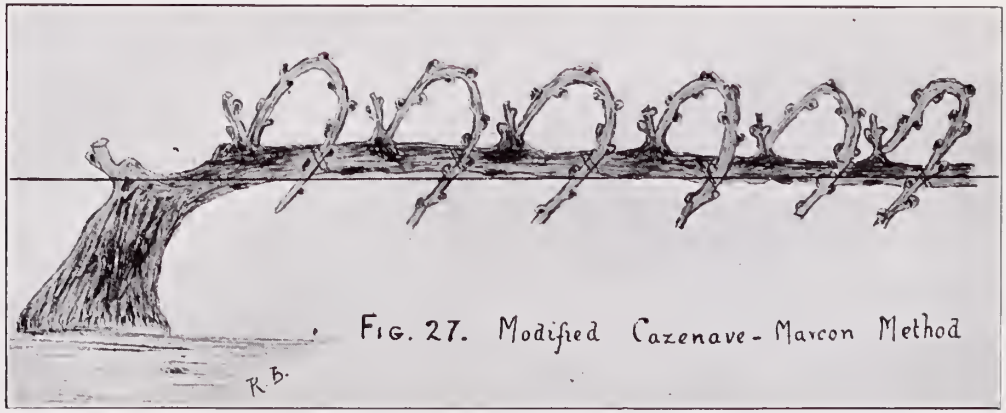


FIG. 26. Cazenave-Marcon System of training.

VINE AFTER SIXTH YEAR'S PRUNING, SHOWING BEARING-CANES TIED IN POSITION.



Vine after Sixth Year's Pruning.

FIG. 28. Chaintres System of training.

FIG. 29. CORRECT CUT FOR PRUNING.

For this method of pruning, the vines should be planted farther apart than for ordinary methods, and the length of the permanent rod will, of course, be regulated by the space between the plants.

Chaintres System of Pruning.

This is another important method suitable for those grapes which allow of great expansion in cultivation. Like the Cazenave-Marcon method just described, it is a modification of the combined system of pruning. It consists of one or more long stems, or permanent rods, running in different directions, and each provided with several subsidiary permanent rods on which the fruit-bearing canes and shoot-producing spurs are grown.

A glance at Fig. 28 will demonstrate to growers how this method is carried out. The rods are supported by small forked sticks driven into the ground. For the purposes of cultivating the ground beneath the vines the forks are pulled up and the rods can be shifted on one side while the ground is being cultivated.

A somewhat similar system has been adopted by growers here for the Isabella, and it is well suited to this grape, the Pineau Gris, and others which, by their robust habits, permit of extended training. It also possesses a great advantage over other systems in that the fruit, being nearer the soil ripens better owing to the radiation of heat from the ground, and the foliage preserves the soil in a moist condition during spells of dry weather.

There are many other methods of training in existence, but those I have described are the best suited to this country.

General Hints on Pruning.

The instruments used for pruning purposes should always be sharp; this enables the operator to make a clean, even cut, without splitting the canes or crushing them. In this country, where extremes of cold are not met with, pruning should begin about a month after the fall of the leaves. The operator should be careful in pruning to begin the cut opposite the terminal bud, and cut upwards in a slanting direction; the manner of making the cut is illustrated in Fig. 29. In pruning, care should be taken to always select the highest shoots for bearing-canes and the lowest ones for wood-producing spurs.

The bearing-canes must always be trained in such a way that the shoots do not become entangled. Instead of training the bearing-canes in a horizontal position it is advisable to incline them downwards and slightly twist them, this checks the flow of the sap to the extremities and causes it to become evenly diffused throughout the system of the vine. Consequently the shoots will grow evenly along the length of the cane

Green or Summer Pruning.

This is the denudation of the vine of that vegetation which is useless to the plant, and detrimental to the production of fruit or wood for the coming season.

Green pruning may be divided into six distinct operations, as under:—

(1.) The rubbing-off of all surplus shoots and suckers from the trunk and rods.

(2.) The removal of all shoots along the bearing-cane which do not show fruit-bunches.

(3.) The stopping or pinching-back of those shoots producing fruit.

(4.) The topping of the wood-producing shoots from the spurs

(5.) The pinching-back of the lateral growths on the fruit-bearing shoots.

(6.) The stopping of the lateral growths on the wood-producing shoots.

Operation (1) is done to remove all surplus shoots from the rod and trunk, which are not only useless, but rob the vine of nourishment, air, and sunshine. The operation is done with the hand or a knife, and at the same time all suckers from the roots of the stock must be suppressed.

Operation (2) is performed by carefully examining the bearing-canes, and removing completely all those shoots not disclosing fruit-bunches. This operation concentrates the vigour of the plant upon the fruit-bearing and wood-producing shoots which remain.

Operation (3) consists of pinching off with the nails of the thumb and forefinger the tips of the *fruit-bearing* shoots. The operation corresponds to the process in tomato and melon culture known as "stopping." Care must be taken in performing this operation that the *wood-producing* shoots are not confused with the *fruit-bearing* ones. The operation is performed by stopping the fruit-bearing shoots at two or three leaves beyond the last bunch. Generally the shoot bears two bunches, but should it only be carrying one the stopping must be performed at five leaves beyond the bunch.

Operation (4) is the topping of the wood-producing shoots, these should be topped at about that length required for the bearing-shoots next season.

Operation (5) is rendered necessary by the stopping of the fruit-bearing shoots (operation 3). This causes the development of the laterals or side-growths, and they are pinched off at two or three leaves. Those, however, on the last bearing-shoot must be left untouched, as they play an important part in attracting the sap for the nourishment of the fruit-shoots. This operation should be made before or after blossoming, but never during the setting of the fruit.

Operation (6), and last, is the stopping of the lateral growths on the wood-shoots. These should be broken off at the fourth or fifth leaf.

Trellising.

In all the systems of training described in the foregoing chapter, with the exception of spur-pruning and the Chaintres method, it is necessary to construct a wire trellis to which the rods, bearing-canes, and shoots of the vine are tied.

As this trellis is required for the whole of the life of the vineyard, it is always advisable to construct it properly and of lasting materials. The straining-posts at the end of the rows should therefore be of totara or puriri. These should be 7 ft. 6 in. long, and the post-holes should be 3 ft. deep, thus leaving 4 ft. 6 in. above the ground. The life of the posts may be considerably lengthened by coating the portion below ground with creosote or tar, which prevents it from rotting. The trellis may be constructed by the ordinary methods of making a post-and-wire fence. The posts should be well rammed, and, to enable them to stand the strain, they should be supported by a cross-piece with one end sunk in the ground and the other fixed in a

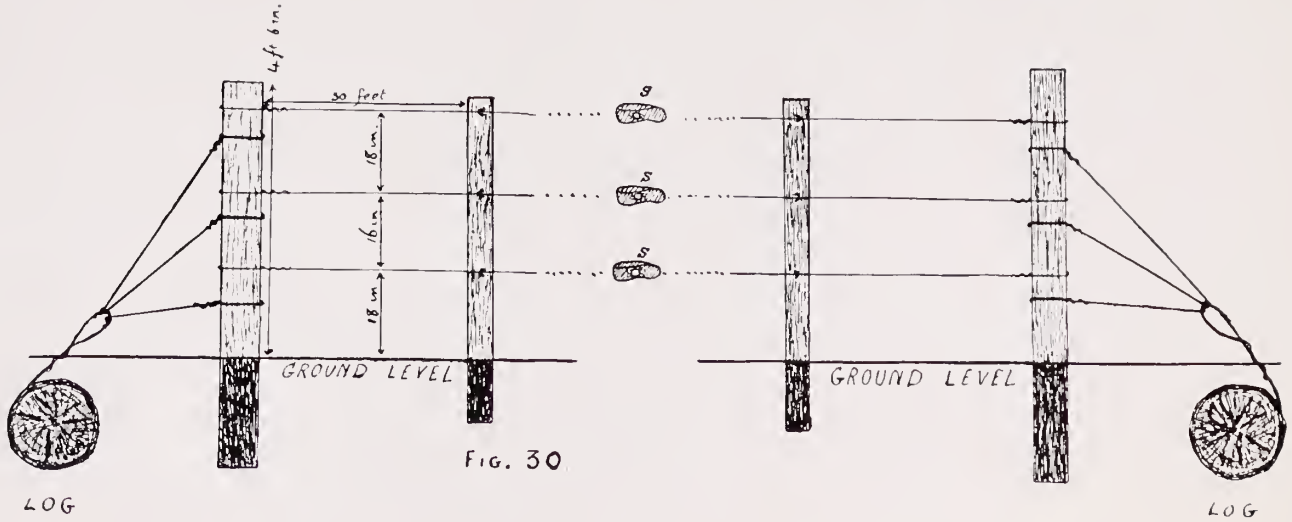


FIG. 30

FIG. 30. TRELLIS FOR VINEYARD.

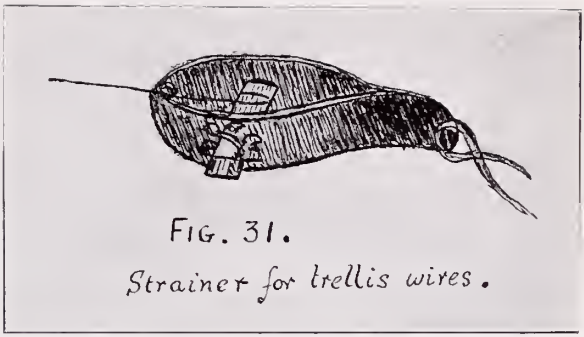


FIG. 31.

Strainer for trellis wires.

notch in the straining-post. The wires should pass through the post to strainers at the back, by means of which the trellis may be tightened when necessary.

Another system largely adopted in wine-growing countries is that of sinking a log in the ground behind the post; a strong wire is fastened to this support, and looped at the other end. To this loop are fastened three wires which are passed from the loop around the post (see Fig. 30). This process is repeated at the other end of the row, and the wires are united in the middle of the row by the strainer shown in Fig. 31. The wire should be plain galvanised wire, and should be supported between the straining-posts by stapling to stakes of totara or puriri at intervals of about 30 ft.

The bottom wire of the trellis should be 18 in. from the ground, and to this is tied the permanent rod or the bearing-cane. The second wire is 16 in. from the bottom one, and this supports the shoots bearing the bunches. The top wire is 18 in. from the centre one, and to this is tied the long shoots from the spurs which form the wood for the coming season.

CHAPTER XII.

MANURING.

In its growth, development, and fruition, the vine demands large quantities of carbon, oxygen, hydrogen, nitrogen, phosphorus, lime, and potash. These chemical elements are as vitally necessary for the vine as food and water are for human beings, and it is imperative that the grower should study the needs of the vine in the direction of foods, and see that it is supplied with a sufficiency.

Of the above-mentioned elements it is unnecessary for the grower to supply the vine with carbon, as this element exists in the atmosphere in the form of carbonic-acid gas, and is supplied to the tissues of the vine by the functions of its leaves. The vine obtains its oxygen and hydrogen from the water in the soil and atmosphere, and, as this substance is usually supplied in abundance, the provision of these two elements (hydrogen and oxygen) need not trouble the grower except in occasional dry spells, when young vines in the nursery or vineyard would benefit by watering or irrigation. With regard to the remaining elements, nitrogen, phosphorus, potash, and lime, the case is different. These food-substances are extracted from the soil of the vineyard in large quantities by the vine; every season when the vines are in full bearing tons of fruit are produced, and an even larger quantity of wood, shoots, and leaves are grown and cut away. It must be obvious to the reader that some return must be made to the soil of those elements which are assimilated by the vine in the bearing of fruit, leaves, shoots, &c., and that the loss sustained by the soil through this continual drain, year after year, upon its supplies of plant-food, must be replaced. Otherwise the soil will become impoverished, and the vine, lacking a sufficiency of its essential foods, will through starvation become weak, sickly, and unfruitful.

It therefore becomes the imperative duty of the grower to pay serious attention to this question of replacing those nutritive elements extracted from the soil by the vine, and, what is more, to return them in such quantities as to keep the soil constantly supplied with these elements, and in the proper

proportions necessary for the health and vigour of the vine. Care must also be taken to make sure that they are administered in such a form as to be easily assimilated by the roots of the plant. It is not sufficient for the grower to dump so much nitrate of soda, so much potash, or so much lime into the soils at intervals. It is worse than useless, and may even be very harmful, to manure the vineyard with substances which the soil is already sufficiently rich in. It would, for instance, be sheer idiocy to manure alluvial loams rich in organic matter with stable manure, or to give a dressing of lime to limestone land. Manuring is a matter in which the grower must be guided by the needs of the soil, the system of training adopted, and the vigour and variety of the vine cultivated; and he must carefully study two questions:- which are the substances most needed, and, how can they be applied in the most efficient and economical manner.

It has been calculated that every season the fruit, leaves, shoots, &c., of the vine deprive the soil of the vineyard of—

From	80 lb.	to	90 lb.	of potash	per acre.
,,	48 ,,		64 ,,	nitrogen	
,,	32 ,,		40 ,,	phosphoric acid	

The bulk of this large quantity of potash is utilised in the production of fruit, the nitrogen for the formation of leaves, shoots, &c., whilst the phosphatic substances are fairly evenly distributed throughout the whole system of the plant. From this we learn that to secure an abundance of fruit we must manure with potash; to obtain a vigorous and healthy foliage and strong bearing-wood we must supply nitrogenous manures; whilst to maintain the vine in a robust condition generally, and insure free setting of the fruit, we should administer phosphatic manures; and the neglect to supply either of these fertilising agencies will cause a corresponding weakness in that function of the vine which is sustained by the elements omitted.

The proportions of potash, nitrogen, phosphoric acid, and lime vary in the different soils, and, although we may know the exact quantities of these substances taken each year from the soil by the vines, unless we know the chemical composition of the soil itself, we are still in ignorance as to what quantities to supply to maintain a proper proportion of each element constantly in the soil. It is necessary, therefore, to have some idea as to the requirements of the different soils and which substances they are likely to be rich or deficient in. This, of course, can only be accurately estimated by a chemical analysis of the soil.

Having noted the substance necessary to be added, the question arises which are the best and most economical manures we can use to supply the deficiencies? Before considering the choice of manures there is another factor to be taken into account, for not only do the manures supply deficiencies in the chemical composition of the soil, but some of them play an important part in changing and remedying the physical or mechanical consistency of the soil. Thus by using stable manure not only do we add the nitrogen and phosphoric acid which is lacking in the soil, but we also alter the consistency of the soil, making it lighter, more porous, more friable, and therefore warmer.

Stable Manure.

For general use in the vineyard and nursery, stable manure is by far the most valuable agent at the disposal of the grower, and I would warn vitieulturists against being led into the exclusive use of artificial fer-

tilisers by the puffing and booming of agents anxious to sell their wares. Artificial manures and chemical fertilisers are invaluable in their proper sphere; but a successful and profitable vineyard cannot be established in clayey, sandy, or poor soils, merely by the application of bonedust, nitrate, potash, or superphosphates. For in addition to these substances—necessary as they are to the health of the plant—the grape-vine must have a sufficient supply of *humus*, or plant-food, formed by the decomposition of animal or vegetable matter; and if stable manure cannot be procured, stockyard manure, leaf-mould, seaweed, fish, or some other decomposed organic matter must be substituted. In the case of animal or vegetable manures, it is of the greatest importance that all these should be well rotted and mellow before being applied to the vine. The grape is not a carnivorous plant which may be fed on raw flesh or fish, neither do rank, fresh, or fermenting manures agree with it. When, however, these substances are well decomposed and broken down, they are the most valuable fertilisers which could be applied.

The carelessness and negligence of many growers here in preparing stable manure for application, or, what is worse still, their total neglect of this "king of manures," as an eminent American authority has termed it, shows how regrettably ignorant they are of its real worth and value in the vineyard; and the fact that it is the most useful fertilising agency they could use, and one which should form the foundation of all manuring, seems almost unknown to them. I would here reiterate and emphasize the fact that the importance and utility of stable manure cannot be too highly estimated. Care must, however, be taken to look after the manure-heaps properly, otherwise a large amount of the value attached to stable manure will be lost before it reaches the soil. In many cases which have come under my notice here, the stable manure is merely dumped in a corner of the stockyard or paddock and allowed to lie there for some time unattended and untouched, or, even worse, the manure is spread on the land in a hot fermenting condition. By thus leaving the manure exposed to the air and rains, the most valuable constituent it contains, the nitrogen, is given off in the form of ammonia, and is either wasted on the air, or is washed away by the rains. Another almost equally important part of the manure is lost in the juices which are allowed to drain away; for these contain the solids of the manure which have become soluble during fermentation. Hence the necessity for covering the manure-heap to prevent any loss by evaporation or through rain washing out the soluble constituents.

Treatment of Stable Manure.

There are two methods of preparing stable manure for use—(1) by building it in a heap above ground; (2) by pitting it below ground. The first method is the best and the one most suited to the climate of this country.

Before making the manure-heap, it is necessary to construct two or more platforms, according to the quantity of manure to be dealt with, at the spot where the manure is to be stacked; and a tank for the reception of the liquids which drain away from the heap and the stable. Where several platforms are used, the tank should be placed in the centre and should be of a sufficient size to allow 3 cubic feet capacity for every 10 square yards of platform-space; a depth of about 4 ft. will be found most convenient. To make sure of the tank retaining the liquids without loss from drainage, it will be necessary to line it with bricks or concrete. The floors of the platforms may be formed

of clay, provided it is well rammed, but in all cases where the floor of the platform is of porous soil it must be covered with concrete to prevent the juices from the manure percolating through and being lost. To further conserve the juices, it is advisable to build a low concrete or brick wall around the platform to a height of 9 in. or 10 in., this will also prevent any water running into the heap from outside.

In choosing the site for the manure-heap, it should be placed in a shady and sheltered position handy to the stable; where such a position cannot be secured and the heap is exposed to the sun and weather, it will be necessary to make a roof for it. In all cases the tank should be covered to prevent loss by evaporation.

The floors of the platforms should be smooth, sloping gently towards the tank, and provided with small drains to assist the drainage of the liquids into the tank.

Having constructed the platforms for the manure-heap and the tank for the liquids, the question of the preparation of the manure has to be decided. This may be done in either of two ways—(1) by maceration—that is, steeping the manure in the liquids for some days until thoroughly saturated; (2) by constantly spraying the manure with the liquids from the tank.

To carry out the first method, the manure is taken from the stable to the tank, and is there allowed to soak for eight or ten days; at the end of this time it is forked out and spread evenly over the floor of the platform and covered with soil or good clay; this should then be firmed by treading all over. The subsequent loads of manure are similarly dealt with, the manure being first of all thrown into the tank to macerate for eight or ten days, then spread on the platform, covered with soil, and trodden.

In the second method of preparation, the soaking in the tank is dispensed with, and the manure placed directly on to the platform. It is then sprayed with the liquid from the tank by means of a force pump, afterwards it is treated as before, being covered with soil and firmed. This spraying is repeated daily, and after spraying, more soil and manure is spread over the heap. This process is repeated until the heap is completed, each day the heap of manure is well soaked with liquid from the tank, and each layer of manure is covered with soil. Not only may soil or clay be used, but it is a good practice to throw house-refuse such as wood-ashes, slops, vegetable waste, &c., upon the heap, together with lime, sand, road-sweepings, hedge-clippings, &c. These substances all decompose in the heap, and, absorbing the juices and gases liberated by the fermentation, form a valuable compost for use in the vineyard or nursery.

When the heap is completed it is covered with a good layer of clay, which is well trodden down. This keeps the rain and sun off it and prevents any loss from evaporation of ammonia or moisture. The heaps should be constructed as rapidly as possible, and fresh manure should not be added to old manure which has been treated for some time.

To judge when the manure has rotted sufficiently for use, a good indication may be found in the liquid which drains away from the heap. If this is still dark-coloured and thick, it shows that decomposition is not yet complete, and the spraying should be kept up until the liquor is clear and almost colourless. When properly prepared, the manure should be sweet and mellow, and should crumble easily when rubbed between the hands.

To many of my readers this treatment of stable manure may seem extravagant. The initial cost of the platforms and tank, and the time and labour spent in preparing the manure, is, however, more than recouped by the

additional value in fertilising-power gained by this treatment. Not only is the whole of the plant-food in the stable manure retained and developed by this method of treatment, but all weed-seeds so common in stable manure are rotted and destroyed.

Gypsum.

A valuable manurial agent which should be used in all cases where stable manure is applied to the land in large quantities is gypsum. This substance is of great value to all soils poor in lime, and should be mixed with the manure-heap in a sufficient quantity to provide a dressing at the rate of 15 cwt. to 30 cwt. to the acre. Gypsum possesses the power of absorbing ammonia in large quantities, and it not only provides the soil with this element and lime, but it has a beneficial effect upon the soil by converting the insoluble potash present into sulphate of potash, in which form it is readily soluble and easily assimilated by the vine.

This combination of stable manure and gypsum supplies the vines with fertilising substances, which, by their slow decomposition, provide a stock of nutriment which lasts for two, three, or even more years, and where the combination has been tried it has been found that more benefit was derived from the manuring than where stable manure alone was applied. So that gypsum should always be used in conjunction with organic or green manuring, as, in addition to supplying lime, it stimulates the vine and assists it to throw strong shoots and profuse fruit-branches.

Mixed Manures.

While a good deal of the plant-foods contained in the stable manure are rendered soluble by proper fermentation and decomposition, the bulk of them are not immediately assimilable by the vine, but decompose slowly in the soil, and so provide a future supply of nutriment. So that it is usually sufficient if a heavy dressing of about 30 tons to the acre is given once every three years.

This would mean that every three years about—

144 lb. of nitrogen,
144 „ potash, and
54 „ phosphoric acid

is given to the soil, and this is equivalent to the addition of

48 lb. of nitrogen,
48 „ potash, and
18 „ phosphoric acid

per year.

But we have already seen on page 42 that from—

48 lb. to 64 lb. of nitrogen,
80 „ 90 „ potash, and
32 „ 40 „ phosphoric acid

are taken from each acre of land every season by the vines in the production of fruit, foliage, shoots, &c. Therefore, while this dressing of stable manure fully supplies the deficiency in nitrogen, it does not furnish a sufficiency of potash or phosphoric acid. So that by stable-manuring alone there is still left a big deficiency between the amount of potash and phosphoric acid taken from the soil by the vines, and the quantity replaced in the form of stable manure.

Artificial Manures.

To manure efficiently and insure the success of the vines, it becomes necessary to supplement the organic manuring by adding sufficient artificial

fertilisers to make up this deficiency in potash and phosphoric acid. To obtain the best results from this mixed manuring, the bone or mineral superphosphates, which are used to make up the balance of phosphoric acid, should be added to the stable manure, as the food-substances they provide are dissolved slowly and not immediately available. The potash manures, which are readily soluble and quickly absorbed, should only be applied when the vine-roots are active, otherwise they will be dissolved by the rains and carried away by drainage.

Stable manure is best applied when the vines are dormant, in late autumn or winter, and it should always be placed deep in the soil, either by opening up trenches or working it deeply in, so as to have it handy to the roots of the vine.

It is difficult to fix any hard-and-fast rule for all soils with regard to the quantity of manure applied or the frequency of its application. These are questions in the deciding of which the grower must use his own discretion or seek expert advice; the quantity used and the times of applying will vary greatly with the nature of the soil, the methods of culture, the condition of the vines, and the variety of grape grown. Generally speaking, poor, light, sandy, and clay soils need heavy dressings; and where great expansion is allowed the vine, and a free-growing variety of grapes is cultivated, a liberal manuring will be required.

We have already remarked that the nitrogen is mostly utilised in nourishing the leaves and stems, hence it is necessary to give the land a heavy dressing of nitrogenous manures before planting and while the vines are employed in growing wood for future use.

Potash.

We have seen that potash is the element most demanded of the soil by the vine, and therefore is the principal one to be considered. We have further noted that the addition of stable manure alone does not furnish a sufficient quantity of this substance to replenish the soil and recoup the losses of potash in the crop of fruit. So that to enable the vine to yield heavy crops of fruit season after season, a considerable amount of potash must be added to the soil in the form of wood-ashes or chemical fertilisers. More than this, most soils are deficient in potash, and with the vines in full bearing the land quickly becomes impoverished and the vines unfruitful; not only does potash assist the vine to bear heavy crops, but it plays an important part in stimulating the formation of sugar in the fruit, and it is upon the quantity of this saccharine matter in the berries that the quality of the wine depends. Consequently, in those localities where the wines are weak in alcoholic strength, and contain an excess of acidity, liberal dressings of potash will usually cause a marked improvement in the quality of the wine, the grapes will ripen better, becoming much sweeter and so producing a must containing less acid.

The most valuable of the potash manures are wood-ashes; these contain as much as 15 per cent. of potash-salts in the form of a carbonate, and this is the best form in which potash can be furnished to the vines. Unfortunately, in its commercial form the carbonate of potash is too dear to use as a fertiliser, and we are compelled to fall back upon the cheaper chemical fertilisers such as kainit, sulphate of potash, and chloride or muriate of potash. The sulphate is the most valuable of these, and yields the best results.

Nitrate of Soda.

This is a very quick-acting and therefore one of the most valuable of the nitrogenous manures. Its use will greatly benefit the vegetation of the vine, which it stimulates and encourages in a marked degree. It is recommended specially for weak vines or those which could not be manured with stable manures on account of unfavourable seasons. It gives better results where the soil contains the proper proportions of phosphoric acid and potash, and is often applied mixed with potash, lime, and superphosphates. Like the potash manures, nitrate of soda is readily soluble in water, and must therefore always be applied when the roots of the vines are active.

The best form in which it can be given is in a combined manure consisting of—

3 cwt. superphosphate,
80 lb. sulphate of potash, } per acre.
80 lb. nitrate of soda

The whole should be well mixed together with an equal quantity of dry sand or earth. This mixture should be sown broadcast and evenly over the surface of the vineyard, and afterwards harrowed in.

When the vegetation of the vine is well advanced, a dressing of ½ cwt. of nitrate mixed with an equal quantity of sand or earth should be broadcasted and worked into the soil to encourage the development and ripening of vigorous bearing-canes for the following season.

Phosphatic Manures.

The effects of an abundant supply of phosphoric acid upon the vine is indisputable after the analytical researches of Muntz and Dubbers. These eminent scientists found that the superiority of the best French and Rhine wines over the commoner ones, was largely due to their richness in phosphoric acid. In addition to this effect upon the quality of the wine, the phosphatic manures have a great influence upon the quantity of the fruit produced. The presence of these manures in a sufficient quantity before flowering induces the vine to throw a large number of fruit-bunches, and it subsequently assists the blossoms to resist the attacks of *couler*, or non-setting of the fruit. These two facts alone show the importance and profitableness of manuring with either bone or mineral superphosphates.

Superphosphates contain about 14 per cent. of phosphoric acid, and should be applied at the rate of two or three hundredweight to the acre, and the best form in which they can be given is mixed with stable manure and worked deeply into the soil. This will provide the vines with an early supply of phosphoric acid from the superphosphates during the blossoming and setting of the fruit, and at the same time give an abundant store of this substance, for nourishing the fruit, from the slow disintegration of the stable manure. The action of the superphosphates will be greatly assisted by the presence of a sufficient supply of potash.

Lime.

This is another substance which is absorbed from the soil in large quantities by the vine, and in most soils it is necessary that this loss should be replaced. The use of lime, however, secures other advantages than merely correcting the deficiency of this substance in the soil, for not only does it nourish the vine with soluble lime-salts, but it neutralises any acidity

of the soil, decomposes the organic matter, improves the mechanical consistency, and liberates any insoluble potash which may be present. Soils rich in organic or vegetable matter are often sour, and by a liberal dressing of lime this sourness or acidity is corrected, and the soil rendered more productive. Stiff, compact, and tenacious soils, such as clays, &c., are greatly benefited by liberal dressings of lime, as it tends to break them down, making them looser and more friable, and so bringing them into a better state of cultivation.

Lime should always be given in the form of air-slaked lime, and that obtained from burnt limestone is much superior to the burnt shell-lime. After the lime has been added to the soil it gradually returns to the form of a carbonate in a finely divided condition, and so is easily absorbed by the plant. This chemical process assists the nitrification of the organic matter, and furnishes the vine with a more abundant supply of plant-food.

Green Manuring.

In many instances here, grape-growers are too isolated from the towns to obtain stable manure in large quantities, and are unable to get a sufficient supply from their own stables to meet the heavy requirements of the vineyard. In these cases, and in all instances where the land is deficient in nitrogen or poor in humus, the soil may be greatly improved by green manuring. This is performed by growing some leguminous crop, such as clover, vetches, field-peas, beans, lupins, &c., and then ploughing them in when they are fully grown and in blossom.

Most plants obtain their supply of nitrogen from the soil, but in the case of the legumes mentioned above the nitrogen is obtained from the atmosphere, where it exists in large quantities.

If a clover or other legume is pulled up and its roots examined, it will be found that the roots are covered with tubercles or nodules. These contain bacteria, known as the nitrogen-fixing bacteria. This name has been given them owing to the property they possess of absorbing the nitrogen from the air, and fixing it in the soil in such a form as to be readily assimilable by the plant. As soon as the legumes begin to grow, these bacteria are developed and begin their work, consequently by the time the crop has fully grown a large quantity of nitrogen will have been added to the soil of the vineyard, and this is retained for the nutriment of the vines by ploughing in the crop. In addition to the nitrogen added to the soil by this means, the stems, leaves, and roots of the crop ploughed in decompose in the soil, and so enrich it with a large quantity of vegetable matter which gradually becomes available as plant-food.

Not only does green manuring supply large quantities of nitrogen and humus to the soil, but the green stuff ploughed in contains a large amount of moisture, which is thus added to the soil, and, when ploughed in, this moisture evaporates but slowly, and is of great assistance to the vines during a dry summer.

The reader will thus observe that numerous benefits are to be derived from this practice. A sufficient supply of nitrogen is added to the soil at but a trifling cost, and the necessity for artificial nitrogenous manures is dispensed with; a large bulk of vegetable matter is applied, which, decomposing, forms humus, and by this means reduces the compactness of heavy soils, and increases the productiveness of light ones, whilst dry and arid soils are improved by the moisture added. Readers, however, must clearly under-

stand that green manuring only furnishes the vine with nitrogenous and organic matter, and does not in any way add to the supply of potash, phosphoric acid, or lime. In fact, the leguminous crop absorbs a large quantity of these substances, and the increased yield of the vines is obtained at their expense. Therefore, in green manuring the necessity for applying potash, superphosphates, and lime or gypsum, becomes intensified.

Time of Manuring.

The best time for general manuring is from the fall of the leaves in the autumn to the rising of the sap in the spring, and this is the proper time for applying all slow-acting manures like stable manure, superphosphates, green-manuring, &c. Quick-acting manures like nitrate of soda, potash, dried blood, &c., should always be administered in the spring, when the buds are bursting and the roots of the vine active, otherwise, being so extremely soluble in water, they will be dissolved by the rains, and, washing into the drains, will be lost without conferring any benefit on the vines.

CHAPTER XIII.

DRAINAGE.

I have already briefly referred to the question of drainage in my remarks upon page 19 in speaking of the preparation of the nursery. I there pointed out that wet soils are always cold and badly aerated, owing to the heat of the sun being absorbed, and the free passage of air to the roots of the plant impeded, by the excess of the water in the soil. And the remarks applied to the preparation of the nursery apply with even greater force to the preparation of the vineyard, where the vine is given its permanent home. The grape needs a warm, well-aerated soil to flourish in, and its root-growth is checked or rendered impossible by the presence of stagnant water. Consequently it is impossible to establish a successful and profitable vineyard in cold, wet, and ill-drained soils. By drainage the excess of water percolates through the soil easily and it becomes more porous, better aerated, warmer, and more easily cultivated.

In some instances, such as sandy soils with a gravelly subsoil, the land is drained naturally, but in the majority of cases it is necessary to resort to artificial drainage. Artificial drainage, carried out efficiently and thoroughly, is always an expensive item in laying down a vineyard, consequently it pays better in the long-run to construct the drains in a permanent manner.

Drainage may be carried out in numerous ways :—

(1.) By means of open drains or ditches.

(2.) By open drains filled in with saplings, tea-tree, branches of trees, &c., and covered with soil; or, in the place of these, by filling in the open drains with large stones, bricks, &c., on top of which is placed smaller stones, gravel, &c., and then covered to the top with soil.

(3.) By means of tile drains.

In the case of open drains they must be kept properly cleared, otherwise they will be faulty and ineffective. The drains filled in with branches of trees, &c., are also liable to become defective owing to the wood rotting and the drains becoming choked. Tile draining is the most expensive method, but at the same time it is the most effectual and permanent, and probably pays best in the end.

Having decided the method of drainage, there are four points for consideration in studying the manner in which the drains shall be laid down:

(1.) The drains should run in the direction of the slope of the land, independent of the furrows or the direction in which the rows of vines are to run.

(2.) The drains must slope evenly, and with a sufficient inclination to remove all surplus water.

(3.) The drains must be at a sufficient depth to drain the soil and subsoil, and always below the level to which the land has been trenched.

(4.) They must be near enough to each other to efficiently drain the whole area of the vineyard.

The direction of the drains must always be dependent on the contour of the land; where the vineyard has a uniform slope in one direction the drains may run at the same depth the whole slope of the land, and parallel to one another, with an outlet to a main drain at the bottom (see Fig. 33). Where there is not a uniform slope side drains should be laid down parallel to each other and connected to main drains (see Fig. 32). The main drains must, of course, be below the level of the side ones.

The inclination of the drains will largely depend upon the slope of the land, but it must always be enough to remove the excess of water in the soil quickly and efficiently.

The depth at which the drains are laid, and the distance between them, will vary with the nature of the soil and subsoil, and the depth to which the land is trenched; the depth will also vary with the distance the drains are apart. Where the drains are widely spaced they must be deeper, as a larger area of land is to be drained.

Generally speaking, in light and sandy soils, which drain easily, the drains should be from 15 to 20 yards apart. In medium soils, from 10 to 15 yards. In heavy clays, &c., from 7 to 10 yards. As a rule the deeper the drains are laid the more efficiently they do their work. The depth varies from 3 ft. 6 in. to 4 ft. 6 in. or more, according to the soil and the distance between them.

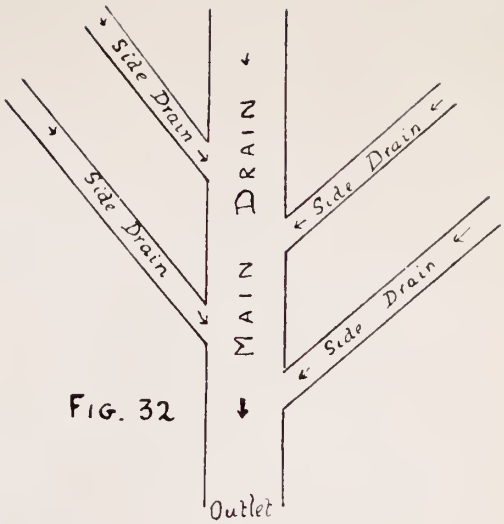


FIG. 32. METHOD OF DRAINING GULLIES OR BROKEN LAND.

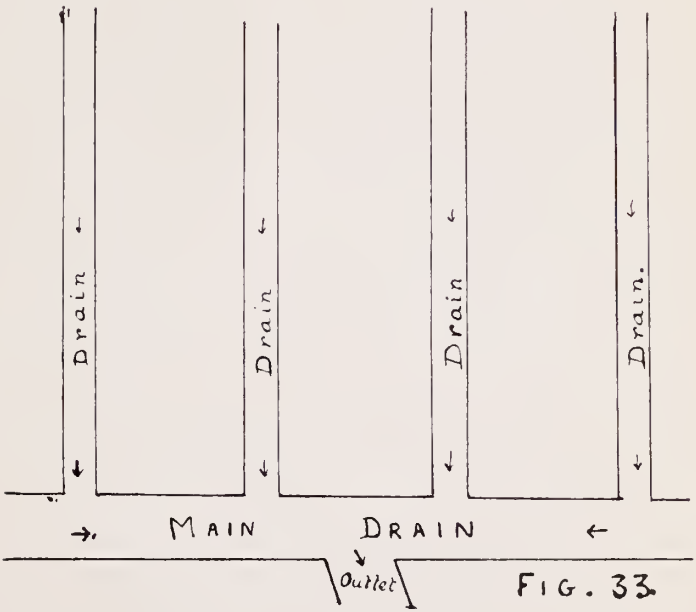


FIG. 33. METHOD OF DRAINING LEVEL LAND OR EVEN SLOPES.

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